S·A·E· JOURNAL

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NOTE: Page numbers above that are preceded by (T) refer to the TRANSACTIONS section (between pp. 24 and 25 of the advertising and news section) containing papers and discussions that will be embodied in the volume of S.A.E. TRANSACTIONS for 1932, to be issued early in 1933.

The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.

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S·A·E JOURNAL

Full Program for Summer Meeting

Technical Sessions of Outstanding Merit Will Fill the Week of June 12 at White Sulphur Springs

ALL signs point to a Summer Meeting that will offer the utmost in professional enjoyment and profit for everyone who is so fortunate as to attend it. From the opening of the General Session at the Greenbrier Hotel, White Sulphur Springs, W. Va., on Sunday evening, June 12, until the closing of the Research Session, at noon on Friday, June 17, topics of extreme timeliness and value will be authoritatively presented by experts and discussed, pro and con, by many leaders in the industry.

The Meetings Committee has planned for the initial session a program of a general nature which will form a fitting prelude to a five-day meeting that has been formulated with the idea of presenting a cross-section of S.A.E. interest.

Monday and Tuesday mornings will be devoted to programs sponsored respectively by the Transportation and Maintenance and the Motorcoach and Motor-Truck Activity. At the earlier of these two sessions, the use of trailers with motor-trucks will be discussed, whereas at the latter the subject under consideration will be power brakes for trucks and trailers. Only one paper per session is planned, so that ample time will be available for the presentation of prepared discussion, after which the session will be thrown open for informal discussion from the floor.

Three Passenger-Car Sessions

The Passenger-Car Activity is arranging for three of the Summer Meeting sessions, the first of which is to be held on Monday evening. Problems of engine and frame design will be given a hearing, and a lively discussion is anticipated.

The Business Session on Tuesday evening will be followed by a novel feature, the details of which the Meetings Committee does not wish to disclose at this time.

The second of the Passenger-Car Sessions is scheduled for Wednesday morning, at which time attention will be devoted to chassis problems. The topics selected for discussion are free-wheeling devices and control, brake drums and brake linings.

Wednesday evening has been assigned to the Passenger-Car-Body Activity for a session at which a paper on the future design and appearance of automobiles will bring out ideas that will be startling to many and interesting to everyone. The same session is expected to include a paper dealing with large stampings and dies used in body work.

Simultaneous sessions are scheduled for Thursday morning, as this arrangement is found necessary to fit into the program the number of worthwhile topics that need to be discussed at this time. It is believed, however, that no serious conflict of interest between the streamlining program and that devoted to Diesel engines will result. The Passenger-Car Activity has planned the program on streamlining, for which two papers have been scheduled. One will deal with streamlining from the viewpoint of radical change in design; the other, with the application of aerodynamic principles to present-day conventional motor-cars.

The Ignition Quality of Diesel Fuels in Cetene Numbers is the title of one of the papers to be presented under the sponsorship of the Diesel-Engine Activity, and a second paper will be announced later.

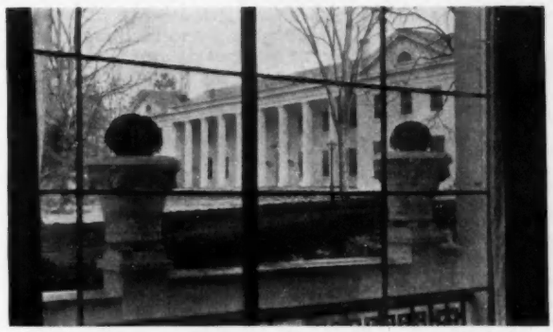
Aircraft and Research Sessions

The Aircraft Session on Thursday evening will consist of a program of a popular nature and this will be followed by the Grand Ball.

A Research Session will be held on Friday morning, at which recent developments in the cooperative fuel research will be presented.

Some evening sessions undoubtedly will appeal to the ladies who attend the Summer Meeting, and, in addition to these more serious events, many opportunities for recreational activity will be provided. No bridge tournament is to be arranged this year, but there will be dancing every evening after the adjournment of the session.

The sports facilities at White Sulphur Springs are too well known to require more than the briefest mention here, and all attending the meeting will find many enjoyable ways of spending such moments of relaxation as may be theirs during a very busy week.



VISTA OF WING OF GREENBRIER HOTEL FROM MEZZANINE WINDOW

Meetings Calendar

General Meetings

Summer Meeting—June 12 to 17

Greenbrier Hotel, White Sulphur Spring, W. Va.

Aeronautic Meeting—Aug. 30 and 31

Hotel Statler, Cleveland

In connection with the Aeronautical Chamber of Commerce of America during the National Air Races

Production Meeting—In Week of Oct. 3

174th Regiment Armory, Buffalo.

In cooperation with the National Metal Congress and Exposition

Transportation Meeting—Oct. 4 to 6

Royal York Hotel, Toronto, Canada

May Section Meetings

Baltimore—May 12

Lord Baltimore Hotel; Dinner 6:30 P.M.

Aeronautic Meeting

Aspects of Commercial Transatlantic Flying—C. H. Schildhauer, General Aviation Mfg. Corp.

Status of Commercial Aviation in the United States Today—Frederick R. Neeley, Aeronautics Branch, Department of Commerce

Motion pictures of the Dornier DOX in flight will be shown

Canadian—May 18

Royal York Hotel, Toronto; Dinner 6:30 P.M.

Motorboats—Herbert Ditchburn, President, Ditchburn Boats, Ltd.

Chicago—May 3

Hotel Sherman; Dinner 6:30 P.M.; Entertainment

Joint Meeting with the Aeronautical Chamber of Commerce of America

Airship Development—V. R. Jacobs, Assistant Manager, Aeronautical Department, Goodyear Tire & Rubber Co.

Engineering and Its Relation to Aviation—Talk by representative of the Aeronautical Chamber of Commerce of America

Motion pictures of the U.S.S. Akron will be shown

Cleveland—May 9

Akron, Ohio

Golf Tournament, Firestone Country Club, 12:00 Noon to 5:30 P.M.

Inspection Trips through Goodrich, Goodyear and Firestone Steel Products plants 2:30 to 5:30 P.M.

Dinner at Goodyear Plant, 6:00 P.M.; Meeting in Goodyear Theatre 7:30 P.M.

New Applications of Rubber from a Research Viewpoint—J. W. Schade, Director of Research, B. F. Goodrich Co.

Influence of Recent Tire Development on Rim Design—W. S. Brink, Development Engineer, Firestone Steel Products Co.

Air Wheels—Rhys Adams, Research Technologist, Goodyear Tire & Rubber Co.

Dayton—No meeting

Detroit—May 9

Book-Cadillac Hotel; Dinner 6:30 P.M.

Engineers Have Lots to Do!—C. F. Kettering

Indiana—May 4

Anderson, Ind.

Joint Production Meeting with American Society for Steel Treating

Visit to Plant of Delco-Remy Corp. in the afternoon

Dinner 6:30 P.M.

Indiana—May 23

Hotel Severin; Dinner 6:30 P.M.

Indianapolis Speedway Race Meeting

Advance Information on Racing Cars and New Trends—Speakers to be announced later

Metropolitan—May 19

A.W.A. Clubhouse, 357 West 57th Street, New York City; Dinner 6:30 P.M.

Joint Meeting with the Aeronautical Chamber of Commerce of America

Engineering and Its Relation to Aviation—J. S. Allard, Vice-President and General Manager, Curtiss-Wright Corp.

Major-General James E. Fechet, former Chief of the Army Air Corps, will talk on Aviation

Milwaukee—May 4

Seaman Body Corp. Plant Inspection Trip, 2:00 P.M.; Dinner 6:30 P.M. at Milwaukee Athletic Club; Entertainment

Development of Automobile Manufacturing in Milwaukee—Harold H. Seaman, President, Seaman Body Corp.

Trends in Automobile Designing—C. H. Bliss, Vice-President and Director of Sales, Nash Motors Corp.

Oregon—May 6

Multnomah Hotel, Portland; Dinner 6:30 P.M.

Properties of Gasoline and Lubricating Oils—Chester Arents, Oregon State College

Pittsburgh—May 18

Norse Room, Fort Pitt Hotel; Dinner 6:30 P.M.

Annual Frolic

Syracuse—May 17

Hotel Syracuse; Dinner 6:15 P. M.

Recent Development of Small Motorboats and Marine Engines—Volney E. Lacy, Designing Engineer, Rochester Boat Corp.

Aeronautic Meeting Highly Successful

More than 600 Attend Student Session—Technical Papers of Superior Quality—Joint Aviation Dinner

OPENING what proved to be one of the most successful and interesting technical aeronautic meetings ever held by the Society, more than 600 members of the Society and students from Michigan schools and universities assembled in the Grand Ballroom of the Hotel Statler at Detroit on the evening of April 5. This opening session, sponsored and staged by the Student Activity of the Detroit Section, was presided over by R. N. Janeway, Vice-Chairman of the Section for Student Activities, and brought to the audience as speakers two of aviation's best known and deservedly distinguished men, Charles S. (Casey) Jones, vice-president of the Curtiss-Wright Corp., and Brigadier-Gen. William Mitchell, U. S. A., retired.

Interspersed with his characteristic humor, Casey Jones's talk on the development and the future of the commercial industry was of extreme interest. General Mitchell, with his usual dynamic presentation, placed before the audience the position of aviation in National defense and pointed out the things that he thought must be done by the United States if it is to develop and maintain supremacy in the air in time of war.

Indicative of the interest that is being taken in the education of the school boy in aeronautics is the contest that was conducted by the Hearst newspapers in 11 States. At this Student Session, Chairman Janeway was able to introduce eight boys from cities all over the United States who won the contest in their respective States and were given free air transportation to and from the National Aircraft Show and expenses while there.

First Day of Technical Papers

The technical part of the program got under way in the morning session on April 6, with T. P. Wright, chief engineer of the Curtiss Aeroplane & Motor Co., in the chair. Chairman Wright was introduced by Prof. Peter Altman, of the University of Detroit. Edward P. Warner gave a discourse on the Rational Specification of Airplane Load Factors, outlining a new method of analyzing the loads on wings and the variation in the different types of aircraft. The great interest aroused by this paper was evidenced by its discussion by J. S. Newell, Mac Short, R. V. Rhode, Ralph H. Upson and other leading engineers in the field of design.

The second paper, on Photoelasticity and Its Application to the Study of Indeterminate Truss Stresses, was presented by the author, D. L. Pellett, of the University of Cincinnati, who accompanied his presentation with demonstrations of the photoelastic polariscope. Following the discussion on this paper, the Chairman called on Lieut.-Com. McCart, of the Bureau of Aeronautics, for some comments on Mr. Warner's paper, and the discussion on the load-factor topic was renewed.

The first session on engines was held in the afternoon, at which two papers, Development Problems of Aircraft Engines of High Specific Output, by R. M. Hazen, assistant engineer of the American Airplane & Engine Corp., and Scavenging a Supercharged Spark-Ignition Engine Using Fuel Injection by ths Use of Large Valve Overlap, by Oscar W. Schey, of the National Advisory Committee for Aeronautics, were delivered.

This meeting convened as a regular session of the Aircraft-Engine Activity. Robert Insley introduced to the audience the Chairman, Charles L. Lawrance, who, as Vice-President of the Society for Aircraft-Engine Engineering, also conducted the business session. A Nominating Committee, consisting of Robert Insley, Chairman; R. M. Hazen, M. J. Steele and N. N. Tilley, was elected, with A. J. Poole and Marsden Ware as alternates. This Committee is to nominate a candidate for Vice-President for Aircraft-Engine Engineering for 1933.

Mr. Hazen's paper proved to be one of the most interesting presentations delivered recently before the Society. Likewise, great interest was shown in Mr. Schey's paper, which was followed by considerable discussion.

Avigation Interests Night Audience

In the evening, one of the most interesting topics of the meeting, Aerial Navigation, was presented by Harold Gatty, now chief navigation officer of the Army Air Corps and best known for his eight-day flight around the world with Wiley Post. This paper was published in the April issue of THE JOURNAL. Considerable time was given to the discussion owing to the extraordinary interest in the methods and equipment developed by Mr. Gatty.

Of no less interest was the paper by Ralph H. Upson, on Flight Control by Air Visualization, giving the theoretical and practical aspects of safe control and blind flying by a unified attitude instrument. This paper also was published in the April issue.

The session convened as a business meeting of the Aircraft Activity, at which William B. Stout, as Vice-President for this Activity, presided, as well as presiding at the technical session which followed. A Nominating Committee consisting of Dr. George W. Lewis, Chairman; Richard C. Gazley, A. E. Larsen and Glenn L. Martin, with C. J. McCarthy as alternate, was elected to choose the Vice-President of the Society for Aircraft Activity for 1933.

Ralph N. DuBois introduced Dr. Lewis as Chairman of the technical session on Thursday morning, as E. E. Wilson, originally scheduled to preside, was unable to be present. One of the first releases of engineering information on the development of the Autogiro ever to be presented was given by A. E. Larsen, chief engineer of the Autogiro Co. of America, in his paper entitled, Engineering Aspects of the Modern Autogiro. This technical analysis of the fundamental engineering features involved in the development and design of this type of craft is of such great interest and value that it is being prepared for publication in full in the June and July issues of THE JOURNAL.

The theory and method involved in the elimination of vibration in four-cylinder in-line engines was discussed by E. S. Taylor, assistant professor at the Massachusetts Institute of Technology, in his paper entitled, Balancing the Four-Cylinder Aircraft Engine. K. D. Wood, of Cornell University, presented some very interesting discussion, as did also S. J. Zand, well known for his vibration research.

Two Good Papers on Maintenance

The cooperation of the Aeronautical Chamber of Commerce and the Society has extended to the field of maintenance engineering, which because of the rapid growth of air transportation and its consequent maintenance problems, has become a matter of consideration both for the manufacturer and the operator. The Aeronautical Chamber arranged, through the Maintenance Committee of its Air Transport Section, a paper to embody the views of maintenance chiefs of all major air-transport lines based upon their experience. Representing the collective experiences of the best minds in this field, the paper, which is particularly significant and worthy of the consideration of manufacturers, was prepared to be presented by Luther Harris, Chairman of the A. C. C. A. Maintenance Committee and superintendent of maintenance of the Ludington Air Lines. Owing to the inability of Mr. Harris to be present, it was presented by Mr. Berchtold, head of the Transport Division of the Aeronautical Chamber of Commerce.

The maintenance session was held Thursday afternoon, April 7, and was presided over by R. C. Marshall, president of the Transamerican Air Lines. The manufacturers' side of the problem and the consideration being given by designers to maintenance requirements, was presented by John G. Lee, project engineer of the American Airplane & Engine Corp. His paper, Maintenance as the Designer Sees It, elicited considerable discussion by Edward P. Warner and George A. Page, of the Curtiss Aeroplane & Motor Co. It is hoped that future meetings of the

(*Concluded on p. 33*)

Philadelphia Section in the Lead

AS the membership campaign draws closer to the half-way mark, it is interesting to note the standing of the various Sections in percentage of applications sent in to the Sections' quotas. Although led by one Section in the number of applications for new membership secured, Philadelphia holds first place in the percentage of quota represented by new applications.

The accompanying table shows the standing of each Section on a percentage-of-quota basis. While these figures are based on number of applications, it should be borne in mind that three months after the close of the contest the awards will be made on the basis of the highest percentage of numbers qualified with relation to the quotas assigned. However, these figures are of interest and should be a stimulus to other Sections to step up and pass Philadelphia.

Reinstating Ex-Members

One of the best potential sources of new members is the group of former members of the Society who, for one reason or another, have resigned or been dropped from membership. Recognizing this, the Council, at its meeting in Detroit on April 5, gave special consideration to the requirements for reinstating such members and decided, for the remainder of the campaign, to make reinstatement available to such ex-members at definitely reduced expense.

The Council decided that, for all former members who resigned in good standing and who make application for reinstatement between April 1 and July 31, 1932, the amount required will be a half-year's current dues. No new initiation fee will be required.

For all members dropped for nonpayment of dues who make application for reinstatement between April 1 and July 31, 1932, the amount required will be the full current year's dues. No initiation fee or back dues will be required.

In such cases it will not be necessary for new applications to be filled out, it being sufficient that a request be made to the New York office of the Society for such reinstatement to membership, accompanied by a check covering the current half-year's or year's dues, after which such applications will be submitted to the Council.

For the purpose of the campaign awards, such reinstatements, when granted, will be counted as new members for the Section and the individual members securing the applications for reinstatement. Therefore, at the time such applications are sent in, the individuals to whom credit should be given should be definitely stated.

Section Standing, April 25

Place	Section	Applications, Per Cent of Quota
1	Philadelphia	38.0
2	Indiana	33.3
3	Canadian	27.6
4	Kansas City	26.2
5	Baltimore	21.4
6	Northwest	20.8
7	Chicago	17.2
8	Pittsburgh	15.1
9	Detroit	12.4
10	Syracuse	12.1
11	Southern California	12.0
12	Metropolitan	11.9
13	St. Louis	9.7
14	Dayton	8.1
15	Northern California	8.0
16	Washington	7.0
17	Milwaukee	6.0
18	Wichita	5.9
19	Cleveland	5.0
20	New England	4.3
21	Buffalo	3.9
22	Oregon	0.0

Campaign Period Half Gone

Although July 31 seems to be a long way ahead, the fact that this campaign has reached the half-way mark should bring a realization of the rapidity with which we are approaching the end. Every Section and individual is urged to speed up this membership work to the utmost so that the Sections and the Society as a whole will finish the campaign with a large number of new members. It is to be hoped that even after the close of the campaign the Membership Committees and the individuals who have given their time and thought to this will continue to function in the same way and bring to non-members throughout the field the value of membership in the Society, to the end that our membership shall continue to increase.

Use the Proper Blank

At the risk of reiterating, attention is again called to the fact that numerous applications are still being received on the regular white form in use prior to the Get-Your-Man campaign. It was, of course, anticipated that many applications would come in in the regular course which are in many ways connected with the campaign efforts, and the rules provide that these have no standing in making the awards.

However, it is still felt that some members working actively on the campaign may be sanctioning the use of the white blank. Except where special notice is given at the time the application is sent in, no credit is being given either to an individual or to a Section for any new member whose application is made on the white blank. A new supply of the special campaign blanks, which are exact duplicates of the regular blank except for the color, has been printed, and these blanks are the only ones that will be used in crediting new members and making the awards.

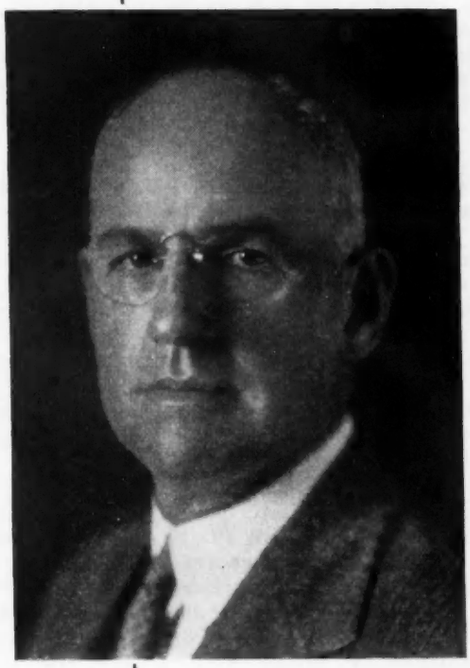
Prospects from the Activities

The determination of names of suitable prospective members, men qualified to join the Society, who by so doing would be benefited both individually and in their work, has progressed through Section organization and individual effort.

Recently the membership representatives of some of the Professional Activities Committees have appealed to the members of the Professional Activity Committee that they represent on the National Membership Committee to send in a list of men in their particular sphere of work whom they believe are qualified for membership in the Society. It is suggested that every member of the Society, whether serving on one of the Professional Activity Committees or not, make a canvass of his field in the industry to determine those who are not now members but who should be.

Personal contact is greatly to be desired and it is felt that everyone can bring to his own friends the advantages of the Society more effectively than can a stranger or a mere acquaintance. However, may we suggest that, if it is impossible for you to make such personal contact, you send to the New York office your list of prospects and an attempt will be made to have some member of the Section or a representative of the Membership Committee get in touch with them. If every member of the Society will take the trouble to send in the name of one good prospect, the membership of the Society will increase rapidly, with benefit to everyone concerned.

Alvan Macauley Urges Vigorous Opposition to Discrimination



Fellow S. A. E. Members:

AT this time, when our industry is making extraordinary efforts to lead in the revival of business and prosperity, I can think of no more urgent message to you than a brief review of the taxation situation that confronts us in Washington. Discriminatory levies against our industry are proposed.

As technical men, you are well aware of the extreme measures in which all of us have participated in order that we might meet present conditions with advanced products at astonishingly attractive prices. Obviously, the imposition of an excise tax would militate against the public interest and might be expected to result in adverse effects upon the 4,000,000 people who obtain their livelihood from the manufacture, sale and use of our products.

Leaders of the industry have vigorously opposed discrimination while expressing a willingness to pay a suitable share of any general taxes which remain necessary after every proper economy in governmental operations has been made effective.

As President of the National Automobile Chamber of Commerce, I am pleased to recognize the important cooperation that S.A.E. members have extended toward the solution of our problems. May I urge upon you the desirability of continuing with all possible vigor toward a happy outcome of our constructive program.

Very truly yours,

Alvan Macauley

Chronicle and Comment

Henry M. Leland IN the passing of Henry M. Leland, our Society has lost a venerable member who was widely held in high esteem for his fine character and accomplishments. Mr. Leland's membership dates from 1909; in 1914 he served as the Society's President with eminent success. His interest in S.A.E. affairs, continuing through the years, has meant much to the Society, and his death has deprived us of a forward-looking pioneer whose sterling personality will be sadly missed.

Past-President J. H. Hunt acted as the Society's official representative at Mr. Leland's funeral. The Council has transmitted a suitable resolution to his son.

Summer Meeting Plans Prosper No greater assurance of an unusually fine Summer Meeting program can be given than the statement that the arrangements are being handled by B. B. Bachman, L. R. Buckendale, A. F. Coleman, C. L. Lawrence, A. S. McArthur, A. J. Neerken, A. J. Poole, D. G. Roos, S. W. Sparrow, W. B. Stout and numerous others. N. G. Shidle, Meetings Committee Chairman, is coordinating the over-all design of the meeting, which promises to be a grand success.

Although the primary objective of this important event is engineering, there will be extra-curricular activities of sufficient variety to assure a well-balanced affair. In this issue of the S.A.E. JOURNAL and in special announcements, the interesting details of the meeting are being brought to light.

Philadelphia in the Lead LIVELY interest, energetic activity and important results mark the progress of the Society's membership work which is being vigorously conducted by Chairman Alex Taub and his Membership Committee in cooperation with Section Membership Committees and the many individuals who are interested in having the benefits of S.A.E. made available to a greater number of qualified engineers.

New applications are numbered in the hundreds. The competitive aspects of the enterprise and the relative accomplishments of our Sections are of particular interest. Elsewhere in this issue a report shows that Philadelphia is leading the procession. Adolf Gelpke and his co-workers are showing what well-directed effort can accomplish.

Riding Comfort THE ACCURACY of objective measuring devices is the best index of the scientific development in any specified field. Judged by this standard, significant advances have been made in the science of measuring riding comfort since the inception of the Society's research project in that field.

Three instruments have been developed in the course of this work: the wabblemeter, which measures the effect of fatigue on general body steadiness and which has been described and demonstrated at recent meetings of the Society; the visometer, developed for studying the effect of fatigue on the visual apparatus, and a reaction-time instrument, which has just been completed and is giving promising results in measuring the length of time a driver takes to move his foot from the accelerator pedal to the brake of the car.

The application of these instruments to the measurement of riding comfort is exemplified by Dr. F. A. Moss, under whose direction the work has been carried out, in his latest progress report, which appeared in the April issue. The future program, recently approved by the Research Committee, includes a large number of road tests taken under varying conditions in which all three instruments are to be used.

Program of Research on Extreme-Pressure Lubricants THE Society's Lubricants Research Subcommittee, having completed its preliminary survey of present knowledge concerning the properties of extreme-pressure lubricants, has formulated and adopted a program of research which is given in brief on p. 25 of this issue.

The Committee's aim is to make available a "yardstick" for evaluating extreme-pressure lubricants so that the refiner can attempt to produce lubricants having the necessary properties and the user can specify such lubricants if desired.

Council Adopts Favorable Reinstatement Policy ACCORDING to a recent ruling of the Council, former members who resigned in good standing may qualify for reinstatement by the payment of one-half year's current dues, no new initiation fee being requird. In the case of former members who were dropped for non-payment of dues, the payment of a full year's dues is required. The Council voted to continue this policy during the period of the Get-Your-Man campaign, which closes June 30, 1932.

Zand Awarded Wright Brothers Medal AMONG the pleasant events that crowded the Aeronautic Meeting in Detroit last month was the presentation of the Wright Brothers Medal to S. J. Zand. The Committee of Award, consisting of E. S. Land, Glenn L. Martin and R. H. Upson, judged Mr. Zand's contribution on airplane vibration to be the outstanding paper of its kind that was presented before the Society in 1931. The paper, A Study of Airplane Vibration with Particular Reference to Vibration at the Instrument Board, was printed in the October, 1931, issue of the S.A.E. JOURNAL.

No award of the Manly Memorial Medal was made for 1931.

Lewis Appointed on Air Committee PRESIDENT SCAIFE, with the Council's approval, has appointed George W. Lewis as the Society's representative on the American Committee on the Marking of Obstructions to Air Navigation.

Hunsaker Chosen for Guggenheim Board J. C. HUNSAKER has been appointed to serve the Society for a term of four years, beginning May 4, 1932, as a representative of the Society on the Daniel Guggenheim Medal Board of Award.

An Automatic Shock-Absorber

By W. S. James[1] and F. E. Ullery[2]

Annual Meeting Paper

HYDRAULIC shock-absorber characteristics are analyzed by the authors with the aid of indicator cards made on a machine designed and built for the purpose. The machine is shown in a diagrammatic drawing and is stated to have been used with much satisfaction for more than two years.

Curves of the action of dry and lubricated springs with and without shock-absorbers attached are shown and the statement is made that the resistance of the shock-absorber does not increase fast enough, as the speed of link movement increases, to damp the spring suitably at both large and small deflections. Indicator cards from shock-absorbers of several types reveal the effects of incorrect design of the valves and of dirt in the oil passages.

The effect of change in viscosity of the working fluid as a result of temperature changes is discussed and attempts to obtain a fluid that is not thus affected are declared to be fruitless. Efforts to design shock-absorbers that compensate for temperature changes have taken the form of (*a*) a relief valve to prevent excessive link force at low temperature and (*b*) a thermostatic element to control restriction of the fluid flow. An inherent disadvantage of the relief-valve type is its limited ability to increase the link force with increase in link speed.

The design of an orifice-control valve which embodies a thermostatic element is shown and described and is stated to have shown remarkably satisfactory characteristics on the laboratory machine and that these have been confirmed on the road. Numerous indicator cards are presented for comparison of the characteristics of a shock-absorber provided with this valve with other types of shock-absorber at various temperatures and rates of link motion. These show that the former gives as rapid a build-up of link force with speed as may be desired, and no manual adjustment on the road is required.

THE importance of riding comfort as a major factor in motor-car satisfaction is unquestioned. The car owner today wants to sit comfortably while driving at high speed over any paved road and many rough gravel and dirt roads. For his own safety and that of others on the road he should have the fewest and simplest possible driving operations to make, so that his whole attention can be given to controlling the direction and speed of the car as traffic and road conditions demand.

Many factors in car design influence riding comfort, such as weight distribution on front and rear axles, spring stiffness to take braking and driving torque, ratio of sprung to unsprung axle weight, ratio of axle and wheel weights to tire stiffness and inflation pressure, seat-cushion spring rates and deflections, seating position, ratio of front and rear spring rates, chassis-spring design and shock-absorber characteristics. Many of these are interrelated and often controlled by other design considerations and compromises. A complete discussion of all factors controlling riding comfort is beyond the scope of this paper, which will deal only with some recent developments in shock-absorber design.

The primary function of a shock-absorber is to ab-

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[2] Laboratory engineer, research department, Studebaker Corp., South Bend, Ind.

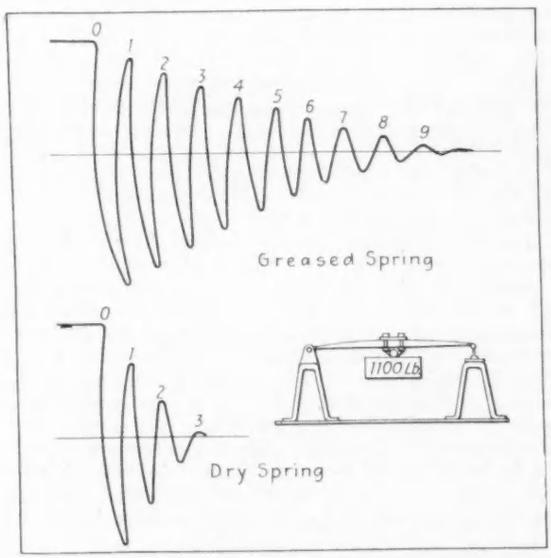


FIG. 1—OSCILLATION OF GREASED AND DRY REAR SPRINGS AFTER RELEASE FROM DEFLECTION

Damping Effect of Interleaf Friction in the Dry Spring Is Very Unsatisfactory

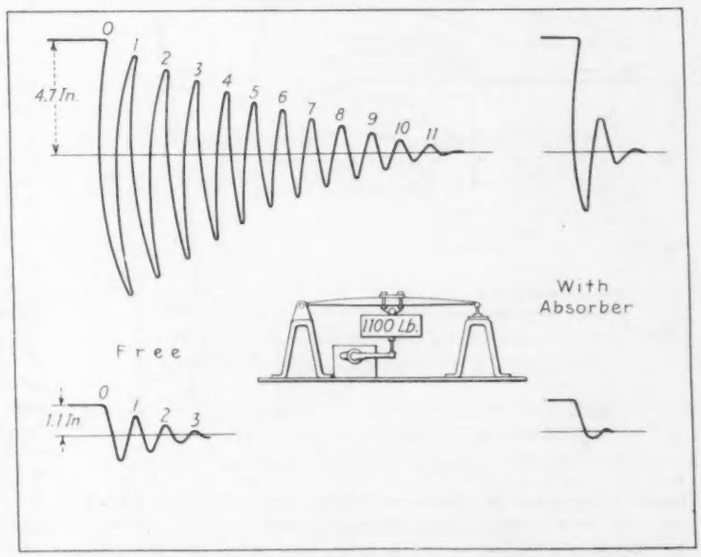


FIG. 2—CYCLES OF A FULLY LUBRICATED SPRING WITH AND WITHOUT A SHOCK-ABSORBER AFTER DEFLECTION THROUGH ITS FULL RANGE (UPPER SERIES) AND THROUGH ONE-QUARTER OF ITS RANGE (BELOW)

sorb the energy stored in the spring during its deflection, thus preventing the throwing of the body and its continued oscillation. Fig. 1 shows the number of oscillations of two rear springs; one dry, the other lubricated, but both loaded with their normal load and deflected, before release, to almost the maximum of their metal-to-metal clearance on the car. The line showing the deflection is curved on the larger deflections because of the linkage used in obtaining the charts. The reduction in damping due to lubrication of the springs is evident. When the spring is well lubricated, it oscillates through nine cycles before coming to rest, whereas the same spring without lubricant oscillates through only three cycles, the friction in the dry spring being about three times that of the lubricated spring. This type of damping is very unsatisfactory and virtually impossible to control because of the variation in the conditions between the spring leaves. It also stiffens the spring and opposes its flexing with axle movement.

Fig. 2 shows the cycles of a fully lubricated spring with and without a shock-absorber when deflected through its full range of movement and also through about one-fourth of its full deflection. The same shock-absorber and the same setting were used with both the large and the small spring deflection. It is evident at once that the strength of the shock-absorber is about correct for the small spring deflection but not sufficient for the large deflection. As the period or time required for a cycle of the spring movement is the same for large and small deflections, it is evident that the resistance of the shock-absorber does not increase fast enough as its speed of movement increases to properly damp the spring at both large and small deflections.

For the purpose of studying the characteristics of shock-absorbers, the machine shown diagrammatically in

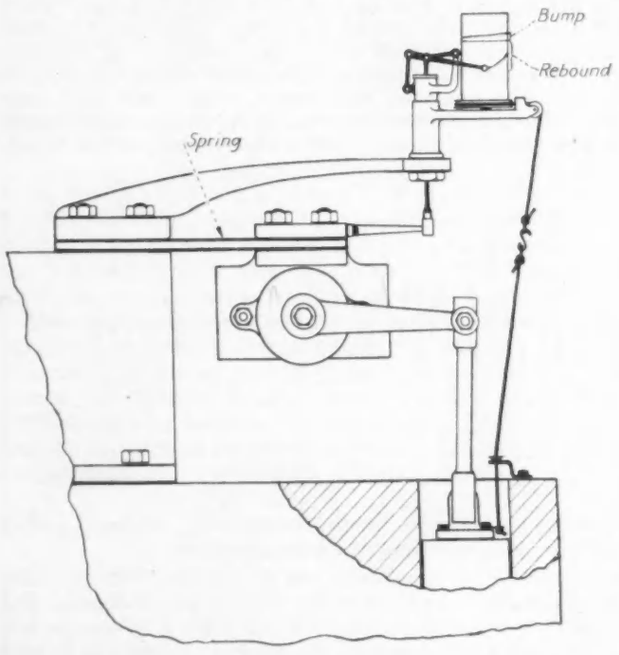


FIG. 3—DIAGRAM OF MACHINE BUILT FOR RECORDING SHOCK-ABSORBER CHARACTERISTICS

The Shock-Absorber Is Mounted on the End of a Stiff Leaf Spring and the Axle End of the Link Is Attached to the Top of a Reciprocating Piston. This Piston Rotates the Drum of a Steam-Engine Indicator at the Speed of the Axle End of the Link, and the Link Force Is Measured by Recording the Deflection of the Leaf Spring on the Chart

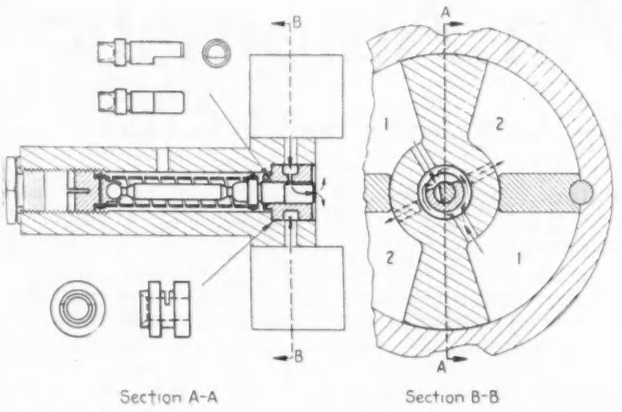


FIG. 7—ORIFICE-CONTROL VALVE THAT HAS GIVEN VERY SATISFACTORY SHOCK-ABSORBER CHARACTERISTICS

A Thermostatic Coil Rotates a Plug Valve in a Slotted Spool. The Plug Has a Milled-Off Flat Portion Which Varies the Flow of Fluid from the High-Pressure Chamber to the Return Passage. The Flow Is More Turbulent than Viscous and the Resistance Increases Rapidly with Increase in Fluid Velocity

Fig. 3 was constructed. In this machine the shock-absorber is mounted on a stiff leaf spring and the axle end of the link is attached to the top of a reciprocating piston. The link force is measured by recording the deflection of the leaf spring with an ordinary steam-engine indicator, the drum of the indicator being rotated at the speed of the axle end of the link. Although somewhat crude, this machine has been used for more than two years and found to be quite satisfactory for the laboratory study of shock-absorbers.

Several cards obtained with this machine and showing some shock-absorber characteristics are given in Fig. 4. Card No. 1 shows the effect of inadequate size of the shock-absorber inlet valve. It will be noted that on both the bump and rebound strokes the pressures do not change with an appreciable movement of the link. Card No. 2 shows the effect of a chattering valve, the waves being produced by the valve opening and closing as fluid was discharged through it. Card No. 3 shows the erratic action of a two-stage valve which cut in and out irregularly at a speed of 150 r.p.m., although at 60 r.p.m. the valve action was steady. Card No. 4 shows the irregular pressure developed on the rebound control and the steadily increasing strength during the bump control when a metering pin having a stepped contour is used. Card No. 5 shows the effect of particles of dirt stopping the oil passages. As the absorber was run, the dirt caused the irregularity at points *a* and *b*, then finally was blown through.

Although the machine reveals defects in the design of shock-absorbers and gives a means of analyzing their erratic action, its principal use has been to study the effect of temperature on and the speed of action of shock-absorbers of a fairly large number of designs. As is well known, hydraulic shock-absorbers of all types are affected by changes in temperature, which change the viscosity of the working fluid. Many attempts have been made to obtain a fluid, particularly an oil, that will not change its viscosity with temperature. Such a search is fruitless. The large change in viscosity of both light and heavy petroleum oils with the changes in temperature encountered in shock-absorbers is shown in Fig. 5.

Two Lines of Development Followed

Two lines of development have been followed in designing shock-absorbers to operate independently of temperature. In one design a relief valve has been

used to prevent excessive link forces at low temperatures, and, in the other design, a thermostatic element has been used to control the restriction of the fluid flow. The relief-valve type has the advantage of simplicity in temperature control but also has an inherent disadvantage of limited ability to increase the link force with increase of link speed. Typical cards of a needle-valve shock-absorber without thermostatic control and of a needle-valve absorber with relief-valve temperature control are reproduced in Fig. 6. The upper two series of cards are at a fixed speed but at different temperatures; namely, 40, 80 and 120 deg. fahr. The effect of viscosity in changing the link force of the needle-valve absorber is very marked. The lower two sets of cards were taken at the same temperature but at link speeds of 60, 100 and 140 r.p.m. The maximum link force of the relief-valve type of absorber is limited by the relief-valve pressure, whereas the link force of the needle-valve type increases more rapidly with speed.

An orifice-control valve of the type shown in Fig. 7 has been found to give remarkably satisfactory hydraulic shock-absorber characteristics. The link force changes but little with change in temperature and increases rapidly with increase in link speed. The latter characteristic makes possible a light control for boulevard driving and an instantly available strong control for high speeds or rough roads. The valve itself is a rotating plug having a flat portion milled off to provide a sharp cut-off edge. The plug rotates in a spool in which a narrow slot has been cut. Fluid from the high-pressure chamber flows into an annular space in the spool, then through that portion of the slot that is opened by the rotating plug and along the cut-away portion of the plug to a return passage below the plug. The length of slot opened to fluid flow is controlled by the temperature of the coil of thermostatic metal. As the slot has a large area in proportion to its length, the flow is more turbulent than viscous, and therefore the resistance to flow increases quite rapidly with increase in fluid velocity. In addition to the effect of tur-

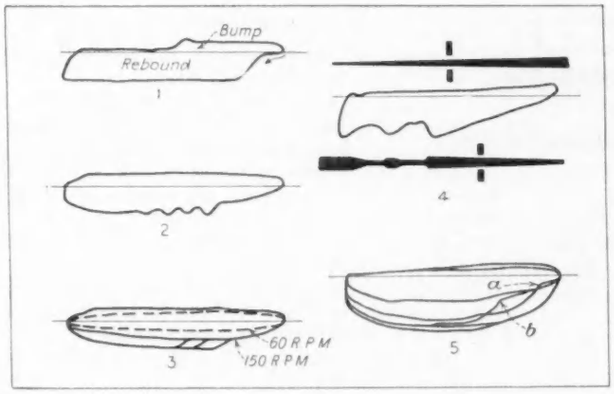


FIG. 4—SHOCK-ABSORBER CARDS TAKEN WITH THE MACHINE SHOWN IN FIG. 3

Card No. 1 Shows Effect of Inadequate Size of Shock-Absorber Inlet Valve; Card No. 2, the Effect of a Chattering Valve; Card No. 3, the Erratic Action of a Two-Stage Valve; Card No. 4, the Irregular Pressure Developed When a Metering Pin Having a Stepped Contour Is Used; and Card No. 5, the Effect of Stoppage of the Oil Passages by Particles of Dirt

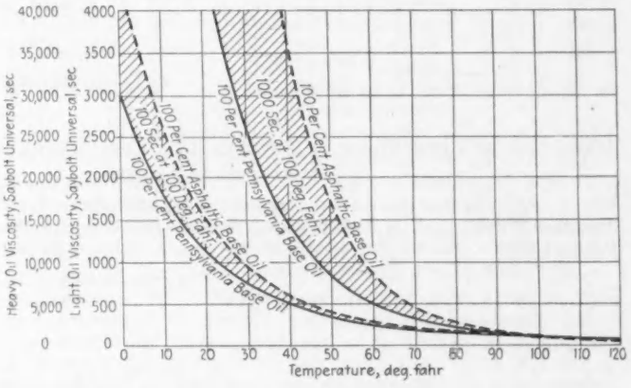

Heavy Oil Viscosity, Saybolt Universal, sec.
Light Oil Viscosity, Saybolt Universal, sec.
Temperature, deg. fahr
100 Per Cent Asphaltic Base Oil
1000 Sec. at 100 Deg. Fahr.
100 Per Cent Pennsylvania Base Oil
100 Sec. at 100 Deg. Fahr.

FIG. 5—CHANGE IN VISCOSITY OF LIGHT AND HEAVY PETROLEUM OILS WITH CHANGES IN TEMPERATURE

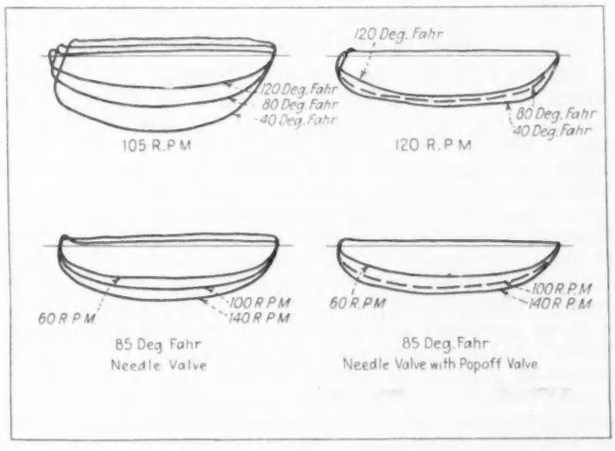


FIG. 6—TYPICAL CARDS OF NEEDLE-VALVE SHOCK-ABSORBERS WITH AND WITHOUT RELIEF-VALVE CONTROL

Cards in the Upper Two Series Were Taken at Fixed Speeds but at Different Temperatures. Those in the Lower Series Were Taken at the Same Temperature but at Different Speeds of the Shock-Absorber Link

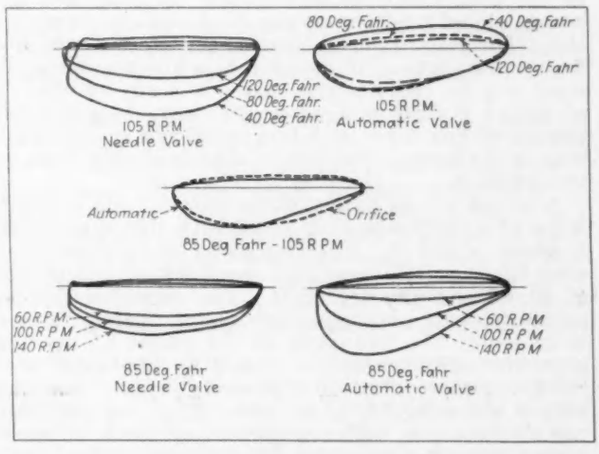
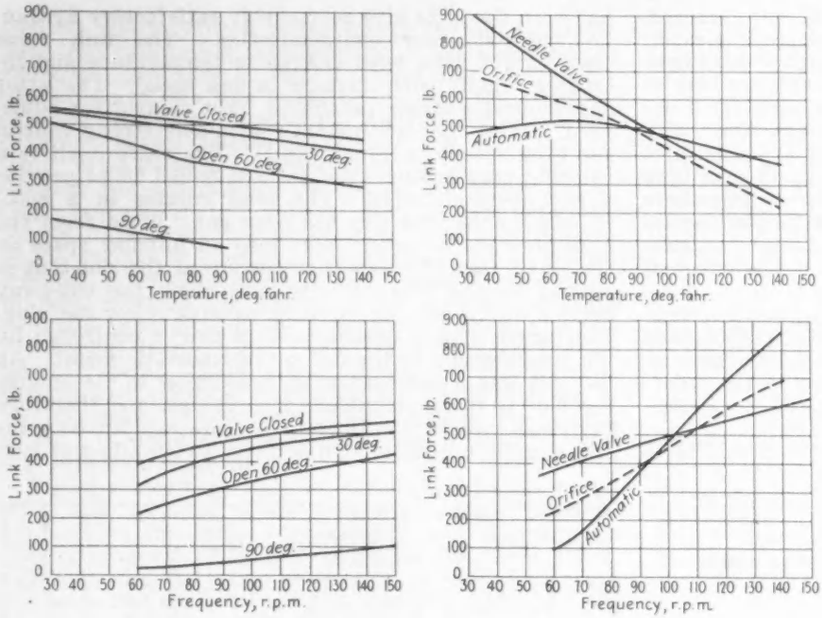


FIG. 8—COMPARISON OF CARDS TAKEN WITH NEEDLE-VALVE AND AUTOMATIC-VALVE SHOCK-ABSORBERS

Cards in the Top Series Were Taken at the Same Link Speed but at Different Temperatures. Those in the Center Show the Effect of Jet Impact on Action of the Shock-Absorber, That Marked "Orifice" Being Taken with a Non-Rotatable Plug Valve and That Marked "Automatic" with the Thermostatic Coil Acting as a Spring and the Plug Valve Free To Rotate. Cards in the Lower Series Were Taken at the Same Temperature but Different Speeds and Show That the Link Force of the Needle-Valve Type Increases with Increase in Link Speed, Whereas the Link Force of the Automatic Type Builds Up Rapidly with Increase of Speed



VARIATION OF LINK FORCE OF SEVERAL TYPES OF SHOCK-ABSORBER WITH TEMPERATURE AND SPEED

Fig. 9—Effect of Temperature on a Shock-Absorber Fitted with a Relief Valve in Parallel with a Needle Valve, at Various Positions of the Needle Valve

Fig. 10—Effect of Temperature on Three Shock-Absorbers Having Different Types of Orifice Control but No Relief Valve

Fig. 11—Effect of Speed on the Same Type of Absorber as in Fig. 9

Fig. 12—Effect of Speed on Same Absorbers as in Fig. 10

bulent flow, an impact effect is produced on the flat side of the plug which tends to rotate the plug to a more nearly closed position as the fluid squirts through the slot. The magnitude of this impact effect can be modified by the contour of the plug face and the spring constant of the thermostatic coil. A study of this type of orifice control will show that any desired rate of change of link force with link speed can be obtained, as well as the desired freedom of change of link force with temperature.

A series of indicator cards showing the characteristics of a shock-absorber fitted with this type of valve is given in Fig. 8. The two series of cards at the top were taken at the same link speed but at temperatures of 40, 80 and 120 deg. fahr. The correction for temperature change accomplished by the thermostatic coil is evident. The two cards in the center of the figure show the effect of the jet impact on the action of the shock-absorber. The card marked "Orifice" was taken with a non-rotatable plug valve. That marked "Automatic" was taken with the thermostatic coil acting as a spring and the plug valve free to rotate. Both valves were set to give the same maximum link force. The lower two series of cards were taken at the same shock-absorber temperature but at link speeds of 60, 100 and 140 r.p.m. The group at the left shows the increase in link force with increase in link speed when a fixed needle valve is used. The cards at the right were taken under the same condition but with the automatic type of valve. The more rapid build-up of link force with increased link speed with the automatic valve is obvious.

Effect of Temperature Change on Link Force

Figs. 9 and 10 are given to show the effect of temperature change on link force in the two general types of shock-absorber. Fig. 9 shows the effect of temperature on the link force of a relief-valve type fitted with a needle valve in parallel with the relief valve. The four curves show the effect of changing the opening of the needle valve, while Fig. 10 shows the effect of temperature on the link force of three absorbers none of which is fitted with a relief valve. The curve marked "Needle Valve" is off an absorber with fixed needle-valve control. The curve marked "Orifice" is off an absorber having a fixed orifice of the turbulent type. The curve marked "Automatic" is off an absorber provided with the thermostatic and impact-type valve. The link force shown on these curves was taken from indicator cards, the maximum of each card being taken for purposes of comparison.

Inspection of the data given in Figs. 9 and 10 shows that

(1) A relief valve is not perfectly free from viscous effects.
(2) A relief valve in parallel with a partly open needle valve, although less affected by viscosity than a needle valve alone, leaves much to be desired as a correction for changes in viscosity.
(3) An orifice having turbulent rather than viscous flow is less affected by viscosity changes than is a simple needle valve.
(4) A thermostatically controlled valve can be virtually independent of viscosity and can be adjusted to give a reduced link force with high viscosities, that is, at low temperatures, to compensate for stiff spring and shackle grease in cold weather.

Figs. 11 and 12 present a comparison of change in link force with change in link speed for the same absorbers used for the data in Figs. 9 and 10. Fig. 11 shows the effect of speed on the link force of a relief-valve type of absorber. Data are given for the needle valve closed and the relief valve operating alone, as well as for several partly open positions of the needle valve. Fig. 12 shows the increase in link force with increase in speed for absorbers without a relief valve. The curve marked "Needle Valve" is for a simple, fixed needle valve. That marked "Orifice" is for an absorber having a fixed turbulent orifice. The curve marked "Automatic" is for an absorber fitted with the type of valve shown in Fig. 7. All three of these absorbers were adjusted to give approximately the same link force at 105 cycles per min., this frequency being that of the spring with which they were to be used.

Conclusions and Proof by Road Tests

Inspection of the curves given in Figs. 11 and 12 lead to the following conclusions:

(1) A relief valve alone has a less rapid build-up of link force with speed than has a needle valve.
(2) A turbulent orifice has a more rapid build-up of link force with speed than has a needle valve.
(3) A valve of the type illustrated in Fig. 7 can give as rapid a build-up of link force with speed as desired.

The foregoing discussion and data do not constitute an orthodox approach to the properties of a shock-absorber. The usual attitude of "Let us have a car and

we will show you a *real* ride" has not been mentioned, nor have the succeeding weeks of argument been described. After several years of this procedure and at least two years of experience with the indicator machine used in parallel with such "rides," it became evident that a good shock-absorber should have at least three qualifications other than construction, manufacture, quietness and the like. These are (*a*) a smooth, regular card, (*b*) the same link force at all temperatures and (*c*) a rapid build-up of link force with increased speed.

When at last these three characteristics were obtained, the resultant ride was looked forward to with some excitement. It exceeded our fondest expectations. The car, when driven at low speed on the boulevard, could give an easy, slow, swinging ride. Such a ride usually resulted in a "wild" ride at full speed over wavy, high-crowned tarred-macadam roads. When the car was driven over this type of road, however, there was no sign of insufficient control and the best high-speed ride yet experienced was obtained. When driven over the same road at slower speeds, no jolts were experienced and an easy, controlled swing was found. When the car was driven over an unpaved railroad crossing at either high or low speed, the car was under perfect control. The higher the speed was, the firmer the springs were controlled, and the driver's ability to control the car was never taxed.

When the car was placed in the cold room, cooled to zero and driven out, the ride was soft at low speed and firm as the speed increased. It was not a jolty "stone-boat" ride, nor was there a frozen set of hand controls to break if forced or useless until thawed out.

In general, the result of an increased rate of build-up of link force with increased link speed, combined with thermostatic control, gave a far more uniform ride whether hot or cold than could possibly be obtained by continual manual adjustment, together with an absolute freedom from fear of being taken unawares by an innocent-looking swell in the road surface, an abrupt culvert approach, an unmarked stretch of rough pavement or some other unforeseen road condition.

THE DISCUSSION

GEORGE P. DORRIS[3]:—What is the viscosity of the oil commonly used in shock-absorbers?

W. S. JAMES:—It varies from about 100 to about 1000 Saybolt sec. at 100 deg fahr.

J. P. STEWART[4]:—In his curves, Mr. James has shown the effect of frequency. I assume that the interpretation in terms of actual car operation is the velocity of the working elements in the shock-absorber rather than a change in frequency of the spring. The shock-absorber action does not change the frequency of the spring, but when the spring motion is large, the velocity of oil flow through the orifice is high.

MR. JAMES:—Mr. Stewart's point is very well taken. What is termed "frequency" in the paper really is link speed. The natural frequency of the spring is independent of the link force. The rear springs have a natural frequency of about 105 cycles per min.

Why Driver Should Not Make Adjustments

LYLE K. SNELL[5]:—I do not believe in hand-controlled shock-absorbers. I think we cannot leave to the driver the adjusting of the shock-absorber to suit himself, because I believe he does not know how it should be adjusted.

A few years ago a man came into our plant and wanted to put on a car a set of what he called shock-absorbers. They were inverted springs to be put on top of the regular car springs to resist their motion. The over-all effect was to increase the resistance of the spring in proportion to the rate per inch of the superimposed spring, stiffening the springs on the car about 30 per cent. Our sales manager became very enthusiastic over this cheme. He drove the car and took a number of dealers out in it and was eager to have the supplementary spring adopted. I could not see any advantage in it and knew that the sales manager's reaction was all psychological. However, after having nearly railroaded through the organization the proposal to get it on the car as regular equipment, he wanted to borrow the car equipped with those springs to drive to Ann Arbor on a Saturday to see a football game.

So I sent the car to the experimental room and told the foreman to "take those shock-absorbers off that car, put them in the back room and keep it absolutely secret, then turn the car over to the sales manager."

The sales manager put eight passengers in that seven-passenger car and drove to Ann Arbor. This was before the roads were paved. Monday morning, after he came back, he called a meeting and brought two or three witnesses to testify that this was a wonderful-riding car. He harangued me at a liberal rate about the riding qualities of that car and called upon his witnesses to tell their story. And they were all enthusiastic, too.

Then the general manager asked what I had to say about it. But I had him call the foreman of the experimental department in to tell exactly what we did to that car.

"Was the car that went to Ann Arbor exactly a standard car?" asked the general manager.

"Yes," I answered. Then I had the car brought out for inspection. We didn't adopt the shock-absorbers.

I am strongly in favor of shock-absorbers, but I do not think that a shock-absorber that depends on the driver of the car for suitable adjustment meets the requirements at all; I think it should be automatic.

Point Where Maximum Control Is Desired

TORE FRANZEN[6]:—The art of producing a shock-absorber that will give a desirable resistance curve is still very young and at least for the present there is room for several schools of thought. May I contribute a line of thought on which I have worked recently, and with which I have had some fair results?

In the upper chart in Fig. 13, which represents a time-displacement curve of an oscillating spring mass, the first cycle is divided into four subdivisions: 1, 2, 3 and 4. The lower chart represents a shock-absorber diagram in which the distances *A* and *B* correspond to heights *A* and *B* in the upper chart.

The distance *R-O* may be covered at a speed greater than that of the natural period of the suspension, as it is made to represent the forced initial impulse, while the time increments t_1, t_2 and t_3 are nearly alike in a conventional suspension. Near point *O* the rate of deceleration and of acceleration is the greatest and the velocity is at the minimum; and I believe that the de-

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[4] M.S.A.E.—Head, automotive laboratory, research department, Vacuum Oil Co., Paulsboro, N. J.

[5] M.S.A.E.—Eaton Axle & Spring Co., Cleveland.

[6] M.S.A.E.—Engineer, experimental division, Chrysler Motors Engineering Laboratory, Highland Park, Mich.

termined maximum shock-absorber resistance should become effective at the beginning of the upward movement of the spring mass, indicated graphically by the full-line curve in the lower diagram in Fig. 13, subdivision 2. As the upward movement progresses, the velocity increases to reach the maximum near the base line, after which the velocity decreases to point O_1. Again following the shock-absorber resistance as indicated by the full line, the resistance decreases as the upward movement continues.

The resistance diagram of Mr. James's shock-absorber resembles the diagram made of the Gabriel friction snubber, and the diagram I have advocated resembles one made of a Watson stabilizer.

The method of studying acceleration is illustrated in Fig. 14. The resulting curves, which resemble those given in Fig. 13, are analyzed by the method illustrated in Fig. 15. The radius of the curve found by this method is translated into acceleration rates. As an example, a radius of ⅜ in. corresponds to an acceleration rate of 22.2 ft. per sec. per sec. in the speed of the chart used. While this method is tedious, it is less so and nearly as accurate as the laying in of tangents and using double integration.

The work is not completed, yet the indications are that control based on the opinions I have expressed will give good results.

Can Now Change the Damping Factor

MR. JAMES:—A shock-absorber cannot make a perfect ride; it can do nothing but damp the movement of the springs. I think that much confusion has resulted from trying to make a shock-absorber do things it cannot do. All that a shock-absorber does or can do is to absorb the energy that is stored in the spring. It lets the spring

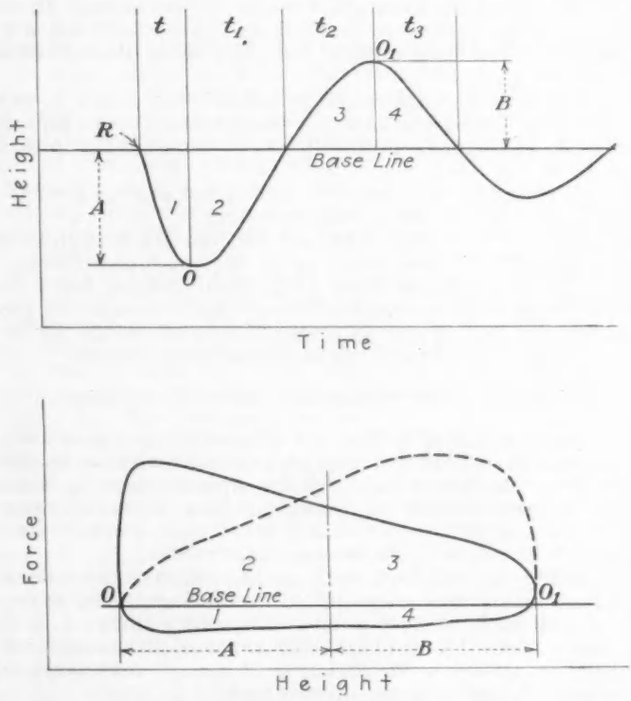

FIG. 13—OSCILLATING-SPRING CURVE (ABOVE) AND SHOCK-ABSORBER DIAGRAM (BELOW)

The Rate of Deceleration and of Acceleration Is Greatest and the Velocity Is at the Minimum Near Point *O*. The Maximum Shock-Absorber Resistance Should Become Effective at the Beginning of the Upward Movement of the Spring Mass, Indicated by the Full-Line Curve in the Lower Diagram, Subdivision 2

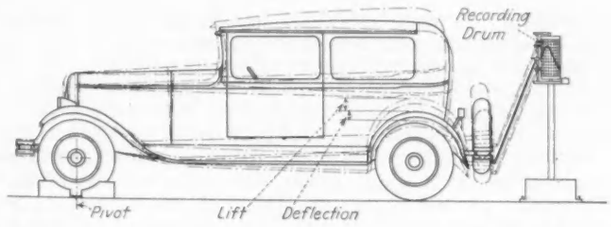

FIG. 14—FRANZEN METHOD OF STUDYING REAR-SPRING ACCELERATION

deflect, and then, instead of the spring reacting and dissipating that energy by tossing the car, the energy is absorbed at a steady rate in the shock-absorber.

The theory of damped vibration usually assumes that the damping force is proportional to speed, and the proportionality factor controls the amount of damping. All the shock-absorber can do is to limit the number of natural swings of the spring and let the spring return to its normal position after a predetermined time or predetermined number of oscillations. The whole point of this paper is that we never have had an opportunity to change this damping factor at all. We could obtain shock-absorbers having a maximum damping factor of about 0.5. This small damping factor is insufficient to enable us to control a fully lubricated spring. The principal advantage of the shock-absorber described is that it enables us to increase this damping factor. I am not in a position to say that we should have a damping factor of 5:1 or of 3:1 or 2:1, but it is a distinct satisfaction to me to know that we can shift it around and get what we wish when we know what we need.

I should have explained that the cards shown in the paper were not obtained with constant link speeds throughout the stroke of the links. If, with any single card, the velocity of the link is plotted against the resistance of the instrument, the result is approximately a straight line.

Control over Rate of Damping Important

MR. FRANZEN:—The linkage of the machine to which I referred undoubtedly was made in a different way than was yours. On our test machines we have very long connecting-rods and come close to harmonic motion.

MR. JAMES:—We were not in position to use much more than a bunch of cylinder blocks and cylinder heads.

MR. FRANZEN:—After all, what is a shock-absorber but an engine functioning backward, consuming power, if you please, instead of delivering it? It is, therefore, an impulse engine consuming a given amount of power in a given time.

New shock-absorber problems have presented themselves with the application of Oilite (sintered metal) inserts in springs. The natural damping of the spring is less severe than in conventional springs, and the calculated period comes closer to the actual. The gain is almost complete uniformity of function. With springs of this type more work must be put on the shock-absorber, and putting it in the right place becomes exceedingly important.

MR. JAMES:—We have been following almost the same line of attack on reducing the interleaf spring friction as Mr. Franzen has. The actual period of the spring depends somewhat upon not only the amount but also the kind of damping. Friction damping resulting from rubbing friction between the spring leaves is virtually independent of speed. I think that the type of damping does not change the period, but that the type of damping which increases the damping in proportion to speed changes the period by an amount that is de-

pendent upon the extent of the damping. The mathematics of the action have all been worked out.

I think, as I have said before, that the control over the rate of change of damping with speed, which has been lacking heretofore, is extremely important, now that we have fully lubricated springs and fully lubricated shackles.

Automatic Adjustment Is Most Desirable

THOMAS J. LITTLE, JR.[7]:—On one of the earlier cars, the Lincoln, which I think was the first American car to have shock-absorbers as standard equipment, we ran into the same difficulty as is being discussed. The shock-absorbers unnecessarily retarded the spring action on good pavement. After very elaborate experimental work and testing and riding and so on, we asked two shock-absorber companies to give us a shock-absorber having a neutral zone of about 1 in. above or below the normal position in which the action of the shock-absorber over the rear-spring travel would be practically cut out. One manufacturer, who was very much on the job, returned to his factory and had a set built in a few days. The results they gave were very gratifying, as the kind of shock-absorber effect desired in the city differed from that desired in the country.

The next logical step is to effect the change manually; to have it available to the operator to make the change at will. Then the ideal development, as Mr. James has mentioned, is to make it automatic so that the driver does not have to think about it. An automatic device, if it works and is infallible, unquestionably is most desirable.

The engineer who did the earlier work on that Lincoln shock-absorber is present and I should like to have him say something about his work since that time.

Reducing the Rate of Spring Build-Up

E. F. ROSSMAN[8]:—With reference to some of Mr. James's curves showing load increases with speed for the two types of shock-absorber tests with the orifice and relief-valve type have shown that the load increase with speed can be varied as desired by the size and shape of the relief-valve discharge orifice and the rate of the relief-valve spring. Our trend, however, has been to hold the rate of build-up after discharge to the minimum and prevent high shock-absorber loadings with the fast axle movement and still get sufficient control.

MR. SNELL:—Springs on a car, if lubricated and assuming there is no interleaf friction, absorb the energy transmitted to the body. The body oscillates back and forth, and the friction of the mechanism finally brings it to rest. Any friction between the leaves will reduce the rate per inch in the necessary movement there. So, if there is considerable interleaf friction, the amount of transmitted work is reduced. We used to build springs having many leaves, and when we cut down the rate per inch the period is slower. I think that the shock-absorber can take part of the work of that spring.

Something was said about all the work being done above the base line. We find that is not a fact. Some of that interleaf-friction work is done below the base line, and therefore we can take some of the steel out of the spring and lower the period of recoil. The period and the amplitude of recoil determine the riding qualities of the car. I believe that when the shock-absorber does part of that work, when we take some of the steel out of the spring and reduce its rate per inch and slow up the period, we are working in the right direction.

Correlation of Absorbers with Spring Period

DR. H. C. DICKINSON[9]:—A question has occurred to me whether a logical, systematic base line exists which might be used to judge whether we have the best possible shock-absorber. We have an undamped vibration represented by a sine wave, and an ideally damped vibration represented by a damped sine wave. The period is not exactly the same as in the undamped sine wave. We have some evidence, which I think is good, that the riding qualities are affected materially by the accelerations; that is, by the slope of this damped sine wave. The slope of the actual curve represents the acceleration. How much that means, I do not know. If this is important and if we assume the same for a curve that represents an ideally damped sine wave, any departure from the latter, no matter how brought about, probably will increase the accelerations compared with those represented by the ideally damped sine wave. Therefore, possibly the object to aim at in devising a shock-absorber is to adjust it so that the car oscillations approach as nearly as possible the damped sine wave of an ideally damped spring. If that is the case, it might be fairly easy to record the actual vibration of the spring and compare that with the damped sine wave to see how closely we have approached the ideal condition.

MR. FRANZEN:—I am acquainted with a shock-absorber built along that line. It should give good results but is highly complicated and I suspect would cost more to build than an engine today. However, Dr. Dickinson's suggestion contains some truth. In this connection I feel sure of one thing—that we do not want a free-center type of shock-absorber.

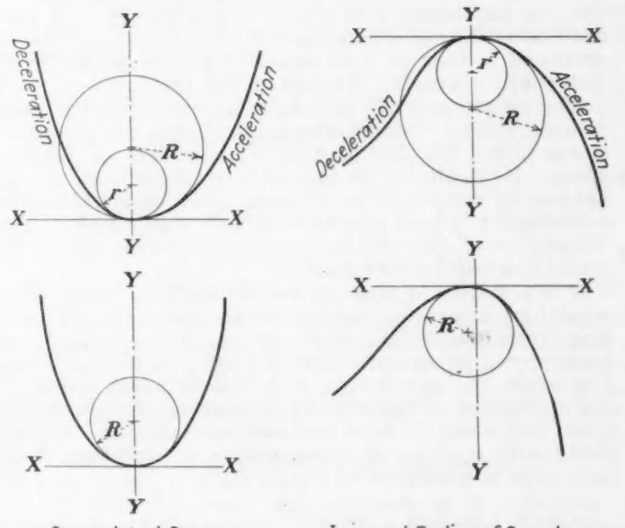

FIG. 15—METHOD OF ANALYZING CURVES FROM RECORDING DRUM IN FIG. 14

The Radius of the Curve Found by This Method Is Translated into Acceleration Rates

[7] M.S.A.E.—Consulting engineer and industrialist, Detroit.

[8] M.S.A.E.—Shock-absorber engineer, Delco Products Corp., Dayton, Ohio.

[9] M.S.A.E.—Chief, heat and power division, Bureau of Standards, City of Washington.

A Possible Criterion for Bearing-Temperature Stresses

By D. P. Barnard[1]

Annual Meeting Paper

THE PAPER suggests a criterion for the tendency toward overheating of plain journal bearings of the high-speed type. The application of a criterion consisting of the product of oil viscosity by the square of the running speed is considered on a heat-balance basis and is compared with a series of observations of crankcase temperatures in a number of typical cars.

Quoting the fact that in a plain journal bearing the coefficient of friction is a function of the term "viscosity times rate of sheer divided by unit load," the author states the symbols and units employed and analyzes heat generation in the fluid film. An analysis of the dissipation of frictional heat is presented also, together with a discussion of the subject of bearing-temperature estimation.

Curves are presented which resulted from data based on observations taken during a series of tests on a number of representative passenger-cars on the Indianapolis Speedway. In conclusion it is stated that the development presented is believed to be sufficiently logical to warrant the serious investigation of the use of the product $\mu_{210}V^2$ as a criterion for temperature rises in high-speed plain bearings.

Major features of the discussion include constructive criticism of the author's premises and methods of analysis, consideration of the effect of counterweighted crankshafts, advocacy that oil men study maximum stress, an analysis of results obtained with a bearing-testing machine, considerations of other actual experimental data and an analysis of oil-film temperature rise.

THE PURPOSE of this paper is to suggest a criterion for the tendency toward overheating of plain journal bearings of the high-speed type operating at values of ZN/P well up in the fluid-film range. Thus far the only criterion which has been used for this purpose is the pv product or "rubbing factor," which, although having the dimensions of a rate of heat liberation, does not actually apply to the case of a bearing lubricated only by a fluid film. Under such conditions the resistance against which motion must be produced is that of fluid viscosity and is affected only to a slight degree by the load on the bearing.

The pv product was originally developed on the basis of solid sliding friction where the resistance is proportional to the imposed load and independent of rubbing speed. Its applicability to a case in which these effects are exactly reversed does not seem justifiable, this being a conclusion which seems to be well verified by a consideration of the relation of the rubbing factor to actual bearing performance.

It is a matter of common experience that under some conditions a bearing having a comparatively low rubbing factor will fail, while under others a high pv product will be entirely satisfactory. In the following discussion the application of a criterion consisting of the product of oil viscosity by the square of the rubbing speed is considered on a heat-balance basis and is compared with a series of observations of crankcase temperatures in a number of typical cars.

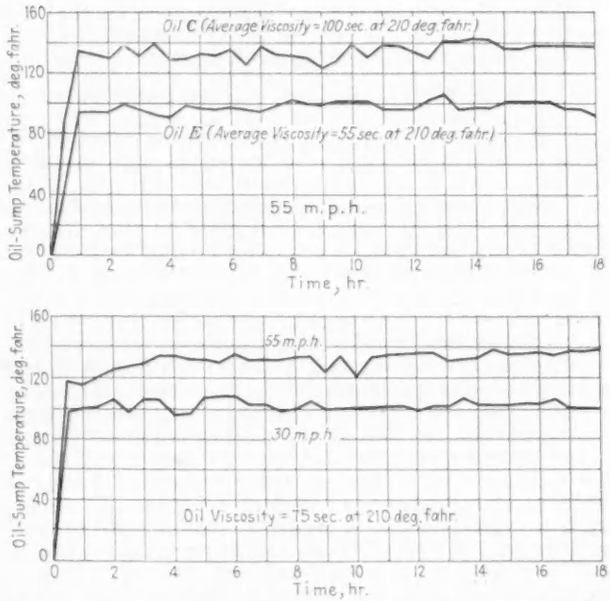
Oil C (Average viscosity = 100 sec. at 210 deg. fahr.)
Oil E (Average Viscosity = 55 sec. at 210 deg. fahr.)
55 m.p.h.
Oil-Sump Temperature, deg. fahr.
Time, hr.
55 m.p.h.
30 m.p.h.
Oil Viscosity = 75 sec. at 210 deg. fahr.

FIG. 1—OBSERVED OIL-SUMP TEMPERATURES FOR CAR NO. 19 DURING SPEEDWAY TESTS

Heat Generation in the Fluid Film

A number of investigators[2] have established the fact that in a plain journal bearing the coefficient of friction is a function of the term:

$$\frac{\text{viscosity} \times \text{rate of shear}}{\text{unit load}}$$

In the fluid-film range the coefficient of friction is actually very nearly proportional to this expression and, using the nomenclature of Table 1, may be written

$$f = K_1 \times (ZN/P) \qquad (1)$$

[1] M.S.A.E.—Research engineer, Standard Oil Co., (Indiana), Whiting, Ind.

[2] Notes on the Theory of Lubrication, by O. Reynolds; *London-Edinburgh and Dublin Philosophical Magazine and Journal of Science*, Series 6, vol. 35, p. 1.
Hydrodynamic Theory of Friction, by A. Sommerfeld; *Zeitschrift fur Mathematik und Physik*, vol. 50, p. 97.
Hydrodynamic Theory of Lubrication, by W. T. Harrison; *Transactions of the Cambridge Philosophical Society*, vol. 22, p. 39.
Laws of Lubrication of Horizontal Journal Bearings, by M. D. Hersey; *Transactions of the American Society of Mechanical Engineers*, vol. 37, p. 167.
The Mechanism of Lubrication, by R. E. Wilson and D. P. Barnard; THE JOURNAL, July, 1922, p. 49.

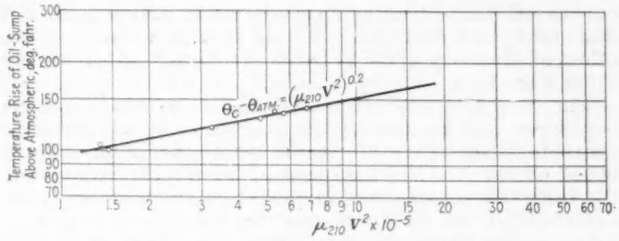

FIG. 2—EFFECT OF OIL VISCOSITY AND CAR SPEED ON TEMPERATURE RISE OF OIL SUMP FOR CAR NO. 19

TABLE 1—SYMBOLS AND UNITS EMPLOYED

Term	Description	Units
f	Coefficient of Friction	None
A	Heat-Dissipating Surface	L^2
D	Journal Diameter	L
L	Bearing Length	L
N	Revolutions per Minute	T^{-1}
P	Bearing Load	$ML^{-1}T^{-2}$
Q	Heat Generated in Unit Time	$MLT^{-2}LT^{-1}$
V	Rubbing Speed	LT^{-1}
Z	Oil Viscosity, centipoises	$ML^{-1}T^{-1}$
μ	Oil Viscosity, stokes	L^2T^{-1}
Θ	Temperature, deg. fahr.	L^2T^{-2}

The work against frictional resistance then becomes

$$\begin{aligned} Q &= K_1 \times (ZN/P) \times P \times \pi DL \times \pi DN \\ &= \pi^2 K_1 ZN^2 D^2 L \\ &= K_1 \mu V^2 L \end{aligned} \qquad (2)$$

Dissipation of Frictional Heat

Heat generated in the fluid film can be dissipated by a combination of conduction, convection and radiation to the crankcase and oil sump. Probably convection forms the principal mode of transfer, with radiation exerting an appreciable influence. The effect of conduction is rather minor. Previously published work[3] indicates that heat loss due to oil flow through the bearing may be expected to be relatively quite small, especially at the higher speeds, when heat generation becomes a matter of real concern. In general, the coefficient of heat transfer by convection increases as the fourth root of the temperature difference in the range under consideration.

From experience in our laboratory, it would be expected that the over-all coefficient for the conditions prevailing around a crankpin bearing would increase in proportion to the 0.3 power of the temperature difference. Main bearings should, no doubt, approcah more closely the fourth-root law. It is doubtful, however, if the possible precision attainable in any heat-flow measurements can justify such small distinctions; hence, for the present purpose, the 0.3-power law is assumed as representative of all bearings on the crankshaft of an automobile engine. Accordingly, the relation between the bearing-surface temperature Θ_B and the effective crankcase temperature Θ_C will be given by

$$Q = K_2 A\ (\Theta_B - \Theta_C)^{1.3} \qquad (3)$$

where K_2 is the over-all heat-transfer coefficient and A is the effective area of dissipating surface.

[3] Oil Flow in Complete Journal Bearings, by D. P. Barnard; THE JOURNAL, August, 1925, p. 205.

[4] See International Critical Tables, vol. 1, p. 32.

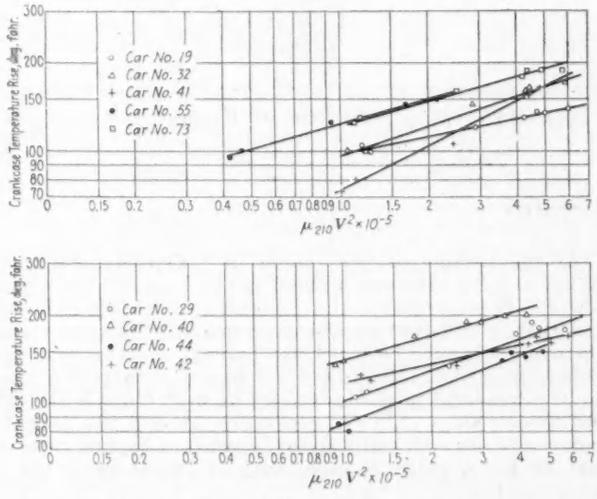

FIG. 3—OIL-SUMP TEMPERATURE RISES OBSERVED FOR DIFFERENT TEST CARS

Bearing-Temperature Estimation

An estimation of the effect of rate of frictional heat-generation on the temperature rises within automobile-engine bearings can be made by equating the

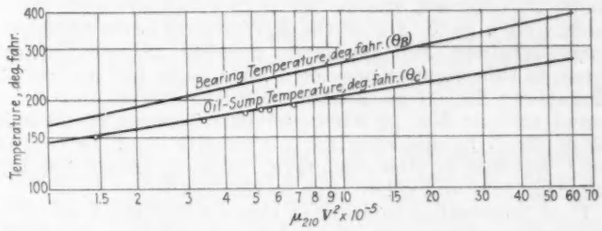

FIG. 4—OBSERVED OIL-SUMP TEMPERATURES AND ESTIMATED BEARING TEMPERATURES FOR CAR NO. 19 AT AN ATMOSPHERIC TEMPERATURE OF 50 DEG. FAHR.

rate of heat generation to that of dissipation, as follows:

$$K_2 A\ (\Theta_B - \Theta_C)^{1.3} = K_1 \mu V^2 L \qquad (4)$$

The coefficient of viscosity at the bearing temperature can be expressed in terms of some fixed temperature[4] in the following manner:

$$\text{Log}\ \frac{\mu_1}{\mu_2} = \rho \log \frac{\Theta_2}{\Theta_1} \qquad (5)$$

or, for the present problem,

$$\mu_B{}^{\rho} = \mu_{210} \frac{210^{\rho}}{\Theta_B} \qquad (6)$$

Substitution of (6) in (4) yields the expression

$$\Theta_B{}^{\rho} (\Theta_B - \Theta_C)^{1.3} = K \mu_{210} V^2 (210)^{\rho} \qquad (7)$$

where $K = (K_1 L / K_2 A)$.

Equation (7) must be solved by trial and error for any particular case; but its form can be illustrated by the curves in Figs. 1 to 6, which are based on observations taken during a series of tests on a number of representative passenger-cars at the Indianapolis Speedway.

Explanation of Curves

It is obvious that any estimate of the effect of the heat-generation term, $\mu_{210} V^2$, on bearing temperature must be predicated upon a knowledge of its effect on the crankcase temperature, as this is known to change markedly with operating conditions. In the following work, the numerical values for *kinematic viscosities* in c.g.s. units (stokes) were employed rather than absolute viscosities. The relative values so obtained are sufficiently representative for present purposes. Fig. 1 shows how the oil-sump temperatures rose above air temperature in the case of car No. 19. These test runs,

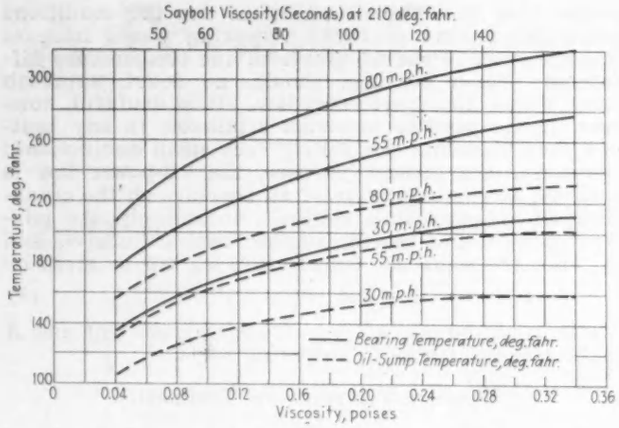

FIG. 5—EFFECT OF OIL VISCOSITY ON BEARING AND OIL-SUMP TEMPERATURES, AS ESTIMATED FROM EQUATION (7)

made at constant speeds for a distance of 1000 miles each, give a good idea of the equilibrium sump temperatures attained, and the large number of observations made in this manner provide a good basis for the use of Equation (7). Fig. 2 shows all the variations in μ_c noted for car No. 19 when driven at speeds of 30 and 55 m.p.h. with oils ranging in viscosity from 58 to 105 sec. Saybolt at 210 deg. fahr. Fig. 3 shows similar data for this and other cars in the test.

It is interesting to note, in this connection, that it is impossible to correlate these data on any basis, such as the *pv* product, which does not provide for the effect of viscosity. No attempt was made to allow for the effect of changing windage on heat losses from the crankcase in plotting these data, the primary object being to show that oil viscosity actually exerts a noticeable influence on heat generation in the bearing as reflected by crankcase temperatures.

At the time this work was done, no effort was made to measure any bearing temperatures. It is therefore impossible to carry the correlation further than the assumption that the rise in sump temperature must, in a large measure, result from the extra frictional heat generated against increasing oil viscosity. Using car No. 19 as an example and assuming that, at 30 m.p.h. and with an oil of 80-sec. viscosity at 210 deg. fahr., the temperature rise of an intermediate main bearing is 30 deg. fahr.—a value obtained by laboratory observations on an engine of similar size—it becomes possible to calculate a series of curves showing the probable effect of the $\mu_{210}V^2$ product on bearing-surface temperatures. This is shown in Fig. 4, together with the observed data for oil-sump temperatures. This plot covers oil viscosities and speeds up to 120 sec. at 210 deg. fahr. and 80 m.p.h. Fig. 5 is a plot showing the effect of viscosity alone at three car-speeds, as calculated from Fig. 4.

Fig. 6 shows the estimated effects on bearing temperatures due to changes in the viscosity-temperature characteristics of the lubricants used. These curves are based on car No. 19 at a speed of 55 m.p.h. They show the insignificant changes in bearing temperatures to be expected for the maximum possible changes in viscosity index on the Dean and Davis scale. In this connection it is interesting to note that no measurable effect of viscosity index on oil-sump temperatures was detected during the car tests.

Conclusions

It is believed that the development as presented is sufficiently logical to warrant the serious investigation of the use of the product $\mu_{210}V^2$ as a criterion for temperature rises in high-speed plain bearings. A survey of data on cars of 1931 models indicates an average value of $\mu_{210}V^2$ of 6.6×10^5 at maximum engine-speeds and with the heaviest oils likely to be employed, the extremes noted being 1.3×10^5 and 13.8×10^5.

The information necessary for a thorough criticism is not available to me, but it is hoped that it may exist in other laboratories and that this suggestion will be checked, both from the viewpoint of relation with temperature rise and with respect to the ratio of heat-dissipating area to bearing length as involved in the constant K of Equation (7). It seems that the value of $\mu_{210}V^2$ might be of considerable use in indicating the necessity for providing means for caring for unusual amounts of frictional heat.

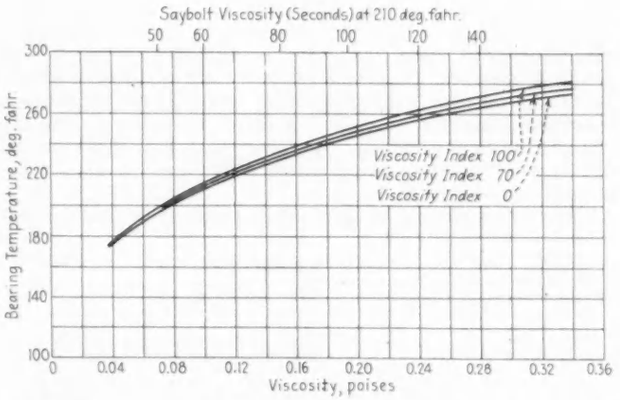
Saybolt Viscosity (Seconds) at 210 deg. fahr.
50 60 80 100 120 140
Bearing Temperature, deg. fahr.
300 260 220 180 140 100
Viscosity Index 100
Viscosity Index 70
Viscosity Index 0
0 0.04 0.08 0.12 0.16 0.20 0.24 0.28 0.32 0.36
Viscosity, poises

FIG. 6—PROBABLE EFFECT OF VISCOSITY-TEMPERATURE COEFFICIENT OF LUBRICATING OIL ON BEARING TEMPERATURE

THE DISCUSSION

R. N. JANEWAY[5]:—I am impressed particularly with the peculiar difference between the functioning of the practical and that of the academic mind when faced by incompatibility between fact and theory. When theory fails to agree with fact, the practical mind discards the theory, while the theoretical mind chooses to ignore the fact. Mr. Barnard's failure to face the facts of this problem is particularly astounding to me because of the classic contributions which he has made to the fundamental theory of the subject, both independently and in collaboration with R. E. Wilson.

At the bottom of the tangle in which Mr. Barnard seems to have involved himself is the bugaboo known as ZN/P. If we examine the derivation of this factor, we find that it is based on the assumption of constant and uniform clearance between the journal and the bearing. This assumption contradicts not only the facts but also the fundamental fluid-film theory as well, since both fact and theory show that the clearance around the journal under any given condition of operation is not only a variable but actually changes with every change in operating condition.

Mr. Barnard himself has very ably brought out in a previous paper, entitled Oil Flow in Complete Journal

[5] M.S.A.E.—Consulting engineer, engineering division, Chrysler Corp., Detroit.

Bearings[6], that the heat generation in a bearing increases rapidly with eccentricity of the journal to such an extent that, according to a curve which he shows, the heat generation due to friction with an eccentricity 0.7 of the total clearance is 2.4 times that at zero eccentricity. Further, G. B. Karelitz showed in a paper entitled An Investigation of the Performance of Waste-Packed Armature Bearings[7], presented in 1929 before the American Society of Mechanical Engineers, that the eccentricity of a journal is a function of P/ZN, or varies inversely as the very same factor which directly determines the coefficient of friction on the basis of constant clearance. It is obvious that, at low values of ZN/P corresponding to high loads, the eccentricity approaches a maximum, thereby tending to offset the tendency for the coefficient to decrease with decrease in ZN/P. Hence, on the basis of true fluid-film theory, the actual tendency for the coefficient of friction to approach a constant value at low values of ZN/P is accounted for. That this is true is clearly shown by the classic analysis of journal friction presented in the paper by R. E. Wilson and Mr. Barnard, on The Mechanism of Lubrication[8] in the portion entitled Fundamental Laws of Fluid-Film Lubrication.

Safe Maximum Duty for a Bearing

In setting up a criterion for bearing-temperature stress, we are obviously interested only in the limiting conditions that define the maximum duty which can safely be put upon a bearing. This range of duty is confined exclusively to low values of ZN/P of the order of 10 to 25, to cite the figures which are given as representative safe values for automobile-engine bearings in the paper[8] just referred to. If we apply a characteristic variation of coefficient of friction with ZN/P, which is given as representative by Wilson and Barnard, namely, $f = 0.002 + [0.000018(ZN/P)]$, we find that, between the limits of ZN/P equal to 10 and to 20, the coefficient of friction actually changes less than 10 per cent. Yet we are asked by Mr. Barnard to accept his relationship of heat generation based upon a direct proportion of friction to ZN/P, which can hold only for the high range of ZN/P corresponding to low speeds with which no one is seriously concerned.

If, in addition to the natural tendency to approach a constant coefficient of friction which is inherent in the basic fluid-film theory, we add the possibility of at least partial breakdown of the fluid film in the limiting range of bearing duty, we have two good reasons for expecting that the coefficient of friction should not decrease with ZN/P in the high-duty range in which we are interested. On the basis of a constant coefficient of friction in this range, which is independent of variations in speed, load and velocity, the total frictional work becomes the function of the product pv. However, without definite information as to the actual limiting value of the coefficient of friction, which is subject to such variables as bearing deformation, continuous variation in magnitude and direction of load, bearing material, oiliness of lubricant and the like, pv becomes merely a relative factor which can be used only when coordinated with experimental knowledge, and then without real assurance.

Fundamental Factors Analyzed

The variables which affect the heat dissipation in a bearing are alone sufficient to make the pv factor a purely speculative criterion. In connection with this phase of the subject, I am at a loss to understand Mr. Barnard's present treatment. In his statement in his present paper that:

> Previously published work[9] indicates that heat loss due to oil flow through the bearing may be expected to be relatively quite small, especially at the higher speeds, when heat generation becomes a matter of real concern.

Mr. Barnard denies the fundamental factor which makes pressure-feed lubrication indispensable to safe operation at high duty.

This statement is a direct contradiction of Mr. Barnard's previous paper[9], in which his analysis of the subject is nothing short of masterful. The following are significant quotations from this paper, the italics being my own.

> The rate of flow of lubricating oil through a bearing is a very important factor in bearing design and performance. This is especially true in the case of high-duty bearings such as are used in automotive engines, steam turbines and certain classes of electrical machinery. The quantity of frictional heat developed in such bearings is large and, frequently, the area of metallic surface available for dissipation of this heat is relatively small. Under such circumstances, *it is necessary that as large a portion of this frictional heat as possible be carried away by the oil in which it is developed, and that it never be allowed to reach the metallic surfaces.*

Mr. Barnard here brings out a fundamental condition of fluid-film lubrication which is basic to the problem of heat dissipation from bearings; namely, that since the frictional work is entirely due to shear in the oil film, the oil-film temperature is necessarily higher than that of the adjacent bearing surface which can receive heat only by conduction from the oil. The oil which flows through a bearing is therefore subject to a rise in temperature due to work done directly upon it, the higher the rate of flow the lower being the temperature rise, and the lower the resulting bearing temperature.

Further, Mr. Barnard shows that the oil flow tends to become a maximum at low values of ZN/P, which is distinctly favorable to direct heat dissipation by oil circulation in the high-duty range and shows experimentally that "oil-feed pressure serves to increase the total flow through a bearing by an amount proportional to the feed pressure," to quote one of his own conclusions.

This earlier fundamental work of Mr. Barnard's makes it doubly difficult to understand his present emphasis on heat loss by convection from the external bearing surface, even disregarding the heat conduction from internal to external surface. I can only repeat my bewilderment that Mr. Barnard, of all investigators, should go so far astray as he has in his present paper from the fundamentals which he himself was instrumental in establishing.

Effect of Counterweighted Crankshafts

W. G. WALL[10]:—In testing the cars on the Speedway, certain ones must have had counterweighted crankshafts. What was the difference in temperature between the main bearings on the cars that had and those that did not have counterweighted crankshafts? We all realize that the high temperature of the oil is caused only partly by the bearings, and that a great deal is caused by other parts such as the pistons. But we know that a bearing which becomes extremely hot affects the temperature of the oil; and, conversely, if the oil becomes hot, it affects the temperature of the bearing. So it would be interesting to know whether any difference in temperature exists in an engine equipped with a counterweighted crankshaft where a large percentage

[6] See THE JOURNAL, August, 1925, p. 207, Fig. 8.

[7] See *Transactions of the American Society of Mechanical Engineers, Section of Applied Mechanics*, vol. 52, paper No. 5, p. 57.

[8] See THE JOURNAL, July, 1922, p. 50.

[9] See THE JOURNAL, August, 1925, p. 205.

[10] M.S.A.E.—Consulting engineer, Indianapolis.

of the pressure is taken off the bearings at, say, ordinary speeds, although it may be that the engine has been designed so that maximum pressure is used on these bearings to keep the bearings down to small dimensions.

D. P. BARNARD:—The car that gave the smallest temperature rise was one which was not counterweighted and probably was the one which carried the highest bearing pressure. The two cars which gave the highest temperature rise, while not having counterweighted crankshafts, did have quite rigid crankshafts of large diameter; probably they were sufficiently stiff so that the bearing stresses were not as high as in some of the other cars which gave rather low temperature rises.

Maximum Stress Should Be Studied

ALEX TAUB[11]:—Every time we hear a discussion of engine bearings by an oil man, we become more and more confused because oil men deal with a condition in which only the oil man is interested. We are not interested in what happens at a running speed of 55 m.p.h. We are interested in the ragged-edge condition where values of ZN/P are low. There is no perfect film lubrication at the ragged edge. It is when we have a job that will not stand up that we are concerned. We are forced to deal with conditions as they exist, which certainly is not perfect film lubrication. I think that the men who know about oil should apply their efforts to conditions of maximum stress. It is useless even to offer suggestions to engineers to ignore pressures; because, if that were possible, we could substitute a set of Ford bearings in a Diesel engine and be perfectly all right. Everyone knows that this cannot be done, and everyone knows that if a critical job is operating with iron rods and iron pistons, a change to aluminum rods and aluminum pistons enables the job to "get by." We know that pressure is a factor; why sidestep it? Let's have it in the picture. Let's find out more about it if we do not understand it or know how to consider pressure properly, because we cannot eliminate it by a pass of the hand.

MR. BARNARD:—Possibly I did not make as clear as I had hoped to that there is no question that the pv product has a considerable significance at low values of ZN/P. However, most of the bearings we have tested indicated that the value is such that they are probably fairly well in the fluid-film range. The principal point of my paper did not seem to get over; namely, the fact that we may really have to begin to worry about failures at the higher speeds, due to overheating and burning out of the bearings. The temperature increases under those conditions can become quite excessive. The car I referred to as an example was one of the best cars we had, from the viewpoint of the probable bearing temperature; some of the others would run at much higher temperature.

Bearing-Testing Machine Used

A. F. UNDERWOOD[12]:—A machine has been devised in the General Motors Research Laboratories to test full-size bearings under actual conditions. It can be operated up to a 10,000-lb. total load with a full-size connecting-rod or plain bearing. A thermoccuple at the surface of the bearing determines the actual temperature under operating conditions. Mr. Barnard gives $H = K_1 \times (ZN/P)$ for the heat generated in the bearing. We have made a number of tests and I thoroughly agree with him that ZN/P does work, but I think most investigators have not gone far enough to thoroughly analyze the facts.

Most curves are plotted as shown in Fig. 7; that is, ZN/P versus coefficient of friction. Equation (1) in the paper is that of a straight line passing through the origin—curve A in Fig. 7. This is not the actual case, because every curve I have ever seen intercepts the coefficient-of-friction axis, giving the equation $H = C + K_1 \times (ZN/P)$, shown as curve B in Fig. 7. At speeds of 70 m.p.h. and over, the bearings are running at a very low value of ZN/P and, in this region, the constant is of major importance in determining the amount of heat generated. It is certain that the general method stated in the paper is along the right lines, but I think that the constant should have been included because it would have given an increase in the amount of heat generated and therefore a higher bearing temperature.

In our bearing-testing machine, in which we control the conditions to be the same as they are on the road, even to the extent of having the load rotate around the bearing instead of being applied only in one direction, we have found that the heat generated in much greater than would be shown by the use of Equation (1).

I am interested to learn that someone has shown that heavy oil makes a bearing run hotter than does a light-grade oil, because we have found exactly the same results on our machine. If a bearing is run on a heavy-grade oil to the point where the oil film breaks down, the use of a light-grade oil actually will make the bearing cooler and, generally, it will run satisfactorily.

Actual Experimental Data Considered

O. C. BRIDGEMAN[13]:—I have heard many discussions of pv as compared with ZN/P. It seems to me that the proponents of both theories are wrong, and yet that both are right. I think that Mr. Underwood has pointed out the answer to the paradox; in other words, both proponents have been considering the problem more from the basis of theoretical considerations, or arguments based on theoretical considerations. Let us neglect the theoretical considerations for the moment and consider actual experimental data, of which many are available. For instance, Mr. McKee has obtained a large amount of information at the Bureau of Standards covering a large range of variables and it is quite precise. Using these data, it is possible to write a general equation for power dissipated in a bearing, which is as follows:

$$H = pv\,[a + (bD/C)\ (ZN/P)]\ LD$$

Using the symbol H for the power dissipated, and the expression pv in the usual sense, we get the power dissipated equal to $pv\ [a + (bD/C)\ (ZN/P)]\ LD$ where D/C and LD take care of the dimensions of the bearing: the diameter, clearance and length.

The relative magnitude of the term a and the term $(bD/C)\ (ZN/P)$ determines whether the important variable is ZN/P or pv. For a bearing running under such conditions that the value of ZN/P is 100 or above, the magnitude of the term a is negligible in comparison with the other, and, changing N from revolutions per minute to circumferential velocity v, the power dissipated is proportional to Zv^2, which is the expression used by the proponents of the ZN/P theory.

However, when ZN/P becomes equal to 40 for a bearing of normal clearance, the two terms become of equal magnitude and both should be taken into consideration. When ZN/P drops down below 40, the first term becomes of greater magnitude than the second term, and then pv becomes of greater significance than Zv^2. At $(ZN/P) = 40$, we are usually still in the region of thick-film lubrication. With a well-run-in bearing we have to go to $(ZN/P) = 10$, or even down to 2, before we get into the region of thin-film lubrication. Hence, over part of the region of thick-film lubrication, the

[11] M.S.A.E.—Development engineer, Chevrolet Motor Co., Detroit.
[12] J.M.S.A.E.—Research engineer, General Motors Corp. Research Laboratories, Detroit.
[13] S.M.S.A.E.—Chief of lubrication and liquid fuels section, Bureau of Standards, City of Washington.

power dissipated in the bearing is directly proportional to pv.

The equation given is based purely on experimental data and, from those considerations, it appears that the particular term to be used for power dissipated depends upon the conditions under which the bearing is being run. Under some conditions, the power dissipated can be represented very closely by Zv^2. Under other conditions, getting down toward the thin-film region, it is represented by pv. Under a good many conditions the two terms have to be taken into consideration.

Oil-Film Temperature-Rise Analyzed

H. C. DICKINSON[14]:—The heat generated at any point in the oil film of a journal bearing is inversely proportional to the thickness of the oil film at that point; and the heat generated per unit volume of oil is inversely proportional to the square of the film thickness. This heat is carried away to the metal surfaces of journal and bearing by conduction which takes place in the moving oil film the same as if the film were at rest, so long as there is no turbulent motion. We know that there is no turbulence in the oil films with which we are concerned.

Calculating the temperature rise in the center of the oil film, which is its hottest point, from the heat generated and the thermal conductivity of the oil, both of which are sufficiently well known, we find that this temperature rise for a given rate of heat generation is proportional to the square of the film thickness. Thus it follows that the rise of temperature at the center of the oil film depends only on the rubbing speed and the oil viscosity, not on the clearance or the eccentricity of the journal in the bearing. Hence it is possible to calculate what the maximum rise of temperature in the oil film is for any given speed and journal diameter. The figures are somewhat as follows: For a 3-in. shaft running at 3000 r.p.m. with a normal grade of oil, the center of the oil film will be about 2 deg. fahr. warmer than the metal; for a 6-in. shaft running at 3000 r.p.m., or a 3-in. shaft running at 6000 r.p.m., the rise will be 8 deg., which is not of much importance even in this extreme case.

This indicates immediately that the oil cannot be used to carry away much of the heat generated in it by friction. Nearly all of this heat goes directly to the metal, and much of it is carried away by the oil which splashes around in the crankcase. If we can supply cool oil to the bearings and take it away hot, this removes heat from the metal; but it would be just about as effective and sometimes safer to circulate the cooling oil through the crankshaft or through some sort of cooling passages as to pump it through the narrow and uncertain clearances of the bearings.

Film Cannot Dissipate Much Heat

MR. BARNARD:—Deflection of the parts, compressive strength of the babbitt and kindred factors also enter the problem and are very important; but there may

[14] M.S.A.E.—Director, heat and power section, Bureau of Standards, City of Washington.

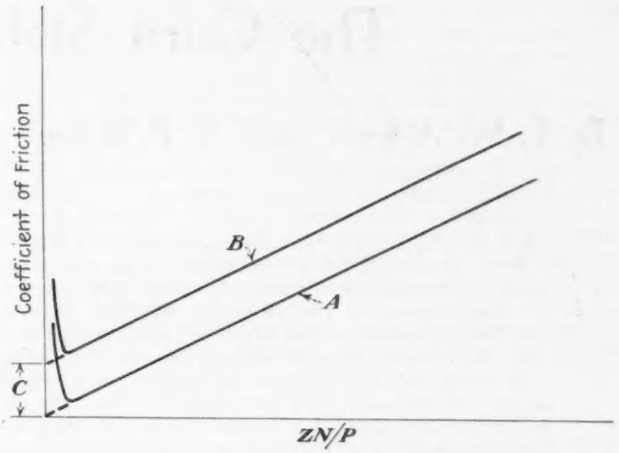

FIG. 7—CURVES ILLUSTRATING THAT A CONSTANT IS NEEDED IN THE EQUATION FOR HEAT GENERATED IN A BEARING

come into the life of every bearing some particular phase of operation in which the heat generated by the shearing of the oil film may really be important. On some of the cars with which we have had experience, such rapid shearing comes in at fairly common driving speeds. From our experience at the Indianapolis Speedway, we sympathize with Mr. Taub's difficulties. We do not need to go to what he would consider the "ragged edge" to get into plenty of trouble due to overheating. The fact is that we do get quite appreciable temperature rises that at least follow oil-viscosity changes, regardless of whether or not they are absolutely proportional to them.

Mr. Janeway criticized the fact that some of the statements which I have made today are a bit at variance with those made in my 1925 paper. Shortly after its presentation, Dr. H. C. Dickinson pointed out to me that there could not be any very appreciable temperature rise between the surfaces of the bearing and the center of the oil film itself. We have come into complete agreement with this and it serves to emphasize the fact that at high values of ZN/P, when, as shown in the 1925 paper, "pumping efficiencies" are relatively small, the oil film itself probably cannot dissipate a very large proportion of the frictional heat.

The actual figures as to the relative values of the coefficient of friction of fluid film and adsorbed film lubrication vary quite widely. The coefficient is not strictly proportional to ZN/P at very low values. At other times it may become fairly nearly proportional to it, *particularly for the bearing*, although not necessarily for the journal, due to the correction which must be applied to the journal load on account of the turning couple. This condition is peculiar to any of the journal-testing machines thus far used. We believe now that most of the heat has to be taken away from the bearing, as Dr. Dickinson has pointed out, by one form or other of heat transfer, different at least from straight conduction by oil flow through the bearing itself.

The Gum Stability of Gasolines[1]

By E. W. Aldrich[2] and N. P. Robie[3]

Annual Meeting Paper

AN investigation of the accelerated oxidation method for predicting the gum stability of gasolines was made to determine the effects of oxygen pressure and of temperature on the observed induction periods. The data obtained on the effect of pressure indicated that there was a definite relation between the induction period at any pressure and the induction period at an air pressure of 1 atmosphere. The data obtained on the effect of temperature showed that the induction periods of different gasolines changed to a different extent with temperature, so that gasolines with the same induction period at any one temperature might have very different periods of stability at storage temperatures.

Since temperature has a marked effect on the observed induction period and since the gasoline is at a lower temperature than that of the bath for a considerable period of time at the beginning of the experiment, a correction factor was applied to obtain true induction periods at the bath temperature. A method is suggested for predicting the length of time for which a gasoline can be stored without excessive gum formation. However, the values obtained are only approximate and further work is necessary to test the validity of the prediction.

Some major subjects of discussion are whether it is necessary to measure the induction period at two different temperatures, how long gasoline can remain in the fuel system befoire resin is formed and definitions of gum and of resin.

ONE of the important phases of the problem of the gumming characteristics of gasolines is concerned with the increase in gum content during storage. Frequently the storage period ranges from six months to two years and, if the gasoline is to be satisfactory as a motor fuel at the end of that period, its gum content must not have become greater than the permissible value for satisfactory engine performance. Obviously, to be able to predict in advance how much gum will be present at the end of the storage period is important.

The problem of predicting how long a gasoline can be stored without excessive gum formation is difficult, for not only is the gum stability a function of the particular gasoline under consideration, but it is also dependent upon the conditions of storage. Furthermore, to verify the significance of any test method, a comparison should be made with the results of storage tests. The immediate problem, therefore, consists in formulating test methods which intrinsically have the best chance of correlating with storage tests. Experiments made by various investigators[4] have indicated that gum formation may be closely related to oxidation processes occurring in the gasoline and hence suggest that the susceptibility to oxidation may parallel the rapidity of gum formation. Accordingly, an oxidation test was the first one investigated, and the present paper covers experiments on accelerated oxidation.

Methods of Accelerating Oxidation

Since the oxidation of gasoline by gaseous oxygen is very slow at ordinary atmospheric temperatures, it is necessary to find some means of accelerating the action to obtain a practical test method. Three means are available: (*a*) increasing the oxygen pressure, (*b*) increasing the temperature during the oxidation process and (*c*) introducing a catalyst.

An increase in the oxygen pressure alone will not, in general, accelerate the reaction sufficiently to permit a test to be conducted in a reasonable period of time; so that, in addition, it is desirable to increase the temperature or to introduce a catalyst. Whereas changes in oxygen pressure alone will not ordinarily change the character of the total oxidation process, increase in temperature or the presence of catalytic agents may exert more effect on certain reactions than on others, thereby making the character of the total oxidation process different from that which occurs during storage. Therefore, it would be necessary to evaluate the effect of either temperature or catalyst and make a correction to a non-catalyzed reaction at ordinary storage temperatures.

In evaluating the effect of temperature, it is possible to follow the usual method of making measurements at various elevated temperatures and extrapolating to the desired lower temperature. The evaluation of the effect of catalytic agents is, however, not so simple; for, ordinarily, only an extremely small quantity of catalyst is necessary and, in general, it is not possible to make measurements with various quantities of catalytic agent and extrapolate to a non-catalyzed state. Accordingly, temperature was chosen as the means for accelerating the oxidation reaction, and the present investigation is confined to a study of the effects of oxygen pressure and temperature on the oxidation of gasolines.

Since the experiments that will be described in this paper were carried out in the absence of catalytic agents, any prediction of gum stability during storage derived from the data obtained must necessarily be limited to conditions of storage such that no catalytic effect enters in. Other limitations may apply as well, since the experiments were conducted with small quantities of gasoline while, in actual practice, gasolines usually are stored in large containers equipped with small breather pipes which restrict ready access of air.

Apparatus

The apparatus and procedure employed in the present investigation are based on the general scheme outlined by Hunn, Fischer and Blackwood[5]. Since the inception

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[1] Publication approved by the Director of the Bureau of Standards of the Department of Commerce. The work herein described was undertaken as part of an extensive investigation of the Gumming Characteristics of Gasolines and was made possible by the cooperation of the United States Army Air Corps.

[2] Junior chemist, Bureau of Standards, City of Washington.

[3] Assistant chemist, Bureau of Standards, City of Washington.

[4] See *Chemical Review*, March, 1927, pp. 113 to 162; also S.A.E. JOURNAL, June, 1929, p. 584; also paper presented by Edgar at the April, 1930 meeting of the American Chemical Society; also paper presented by Ramsay at the September, 1931, meeting of the American Chemical Society.

[5] See S.A.E. JOURNAL, January, 1930, p. 31.

of the work, similar schemes for accelerated oxidation have been published by Ramsay[6] and by Zublin.[7]

A diagram of the type of oxidation bomb used in these experiments is shown in Fig. 1. The bombs proper were made from standard brass tubing closed at the bottom by a brass plug forced in on an arbor press and, after locking in position with four steel pins, the joint was made tight with tin solder. At the top, a flange was screwed on and a recess was provided for a lead gasket. The bomb was closed by a thick brass disc, and the closure on the lead gasket was made tight by five cap-screws. Threaded into the top and soldered with tin was a length of 1-in. brass hexagonal rod suitably provided with passages leading to a needle valve and through a coil of 1/16-in. copper tubing to a calibrated pressure gage. The coil of copper tubing was introduced between the bomb and the gage to minimize the condensation of gasoline in the gage and would also be effective in damping a detonation wave if autoignition should occur. The needle valve furnished a means of introducing oxygen. Six bombs of this type were constructed and, while brass was used for convenience and to avoid rusting, it might be preferable in general to employ stainless steel, which has a higher tensile strength than brass. Oil sample bottles of 8-oz. capacity were used as gasoline containers to be inserted into the bombs. A thin cork disc was placed at the bottom of each bomb before insertion of a sample bottle to lessen the chance of breakage if the bomb should be jarred.

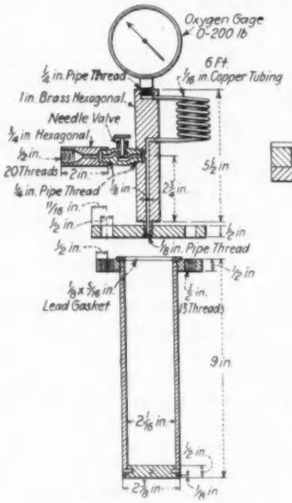


FIG. 1—BOMB FOR ACCELERATED OXIDATION TESTS

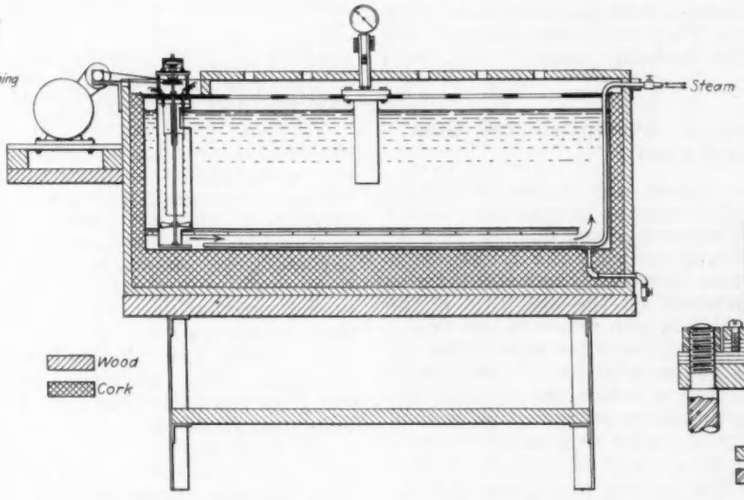


FIG. 2—THERMOSTATED BATH FOR ACCELERATED OXIDATION TESTS

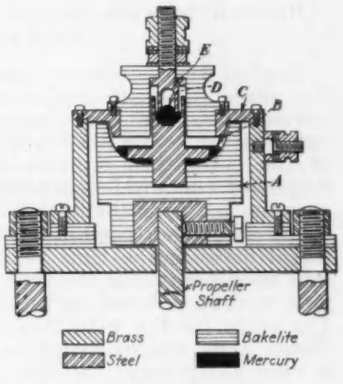


FIG. 3—SAFETY SWITCH

Additional apparatus consisted of an oxygen supply tank, an ice bath and an electrically heated oil bath. The oxygen supply tank was fitted with a charging line provided with a relief valve and, during the process of filling, the bomb was connected to it by a cone joint. The ice bath was simply a copper-lined box sufficiently large to hold six bombs. The oil bath, a diagram of which is shown in Fig. 2, was constructed of brass and was placed within a wooden box, the space between the box and the bath being filled with finely divided cork for insulation. The bath liquid was 300-deg. mineral seal oil. The oil was circulated by an electrically driven stirrer operating in a tube, which drew the liquid down through the tube and forced it out under a false bottom to the other end of the bath. The temperature throughout the bath was uniform during an experiment to within 0.2 deg. cent. (0.4 deg. fahr.). Rapid heating was accomplished by steam under pressure passing through a coil of copper tubing under the false bottom. An electric heater and a mercury-in-steel thermo-regulator were used to maintain the bath at the desired temperature. A brass plate containing six holes through which the bombs were inserted formed the top to the bath and also supported the bombs during the experiments. A split wooden top with holes to accommodate the hexagonal tubing connected to the bombs was also provided.

To the top of the stirrer was connected a safety switch which was designed to cut off the current to the heater as soon as the stirrer stopped moving. A diagram of this device is shown in Fig. 3, drawn to scale. When the stirrer is operating, the mercury in the large bakelite cup *A* is displaced upward by the centrifugal force and makes electrical contact between the rotating steel disc *B* and the stationary steel ring *C*. The clearance between the rotating and the stationary pieces was made small so that the mercury would not be thrown out of the cup. Electrical connection to the rotating steel disc in the large cup was made through a steel shaft, set in the bakelite, to a small mercury cup *D* in which dipped a stationary steel rod *E* leading to a binding post. This electrical device was made part of the heating circuit so that if the stirrer stopped, due to the belt breaking or the motor burning out, the circuit to the heater was broken. Some automatic device of this nature is considered advisable when runs are made over night in the absence of the observer.

Procedure

In making an experiment, 100 ml. of filtered gasoline was transferred to an 8-oz. oil-sample bottle which was then placed in the bomb. A cap, made by cutting off part of a Soxhlet extraction thimble, was inserted over the neck of the bottle to keep out any foreign matter, and the cover of the bomb was securely fastened in place. The bomb was then placed in the ice bath at 0 deg. cent. (32 deg. fahr.) and connected through the needle valve to the oxygen supply tank. The air in the bomb was flushed out twice by introducing oxygen

[6] Paper presented at the September, 1931, meeting of the American Chemical Society.

[7] See *Oil and Gas Journal*, July 16, 1931, p. 26.

under a pressure of 100 lb. per sq. in. and then releasing the pressure each time. Oxygen was again introduced to a pressure 20 lb. per sq. in. in excess of the initial oxygen pressure desired. After 20 min., final adjustment of the pressure was made. The bomb was then transferred from the ice bath to the oil bath maintained at a chosen temperature between 80 and 120 deg. cent. (176 and 248 deg. fahr.). Normally, three samples were run in duplicate at the same time, and, as soon as the bombs were in place in the bath, the temperature was rapidly restored to the desired value by superheated steam and additional electrical heating. Usually this took only 2 or 3 min. Pressure readings were then taken periodically during the course of the run. At the end of the experiment, the bombs were cooled in the ice bath for 30 min., the pressure was released slowly and the samples were removed from the bombs. After each run the bombs were cleaned with an acetone-benzene mixture and dried before they were used again. The bottles were cleaned with alcoholic potash, rinsed with water and dried.

Relation between Oxygen Absorption and Gum Formation

Typical time-pressure curves are shown in Fig. 4 for three different initial oxygen pressures. These curves show that the pressure rises due to rise in temperature while the bomb attains the temperature of the bath, then remains essentially constant for a length of time which depends on the stability of the gasoline and upon the initial oxygen pressure and finally drops as oxygen combines with the gasoline. The interval between the time of introduction of the bombs into the oil bath and the time at which the pressure begins to drop is taken as the observed induction period. The value for the induction period was not difficult to choose from the plotted data, since the pressure drop is very sharp except at low oxygen pressures. Duplicate values agree very well, the average difference being about 5 min. This is shown in Fig. 5, which is a plot of the deviations from the mean in the case of duplicate determinations against the mean induction period.

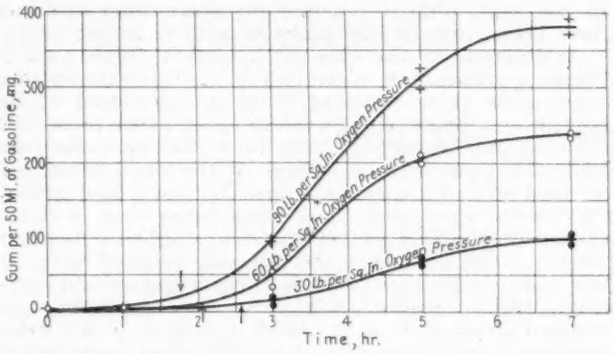

Gum per 50 Ml. of Gasoline, mg.
Time, hr.
90 Lb. per Sq. In. Oxygen Pressure
60 Lb. per Sq. In. Oxygen Pressure
30 Lb. per Sq. In. Oxygen Pressure

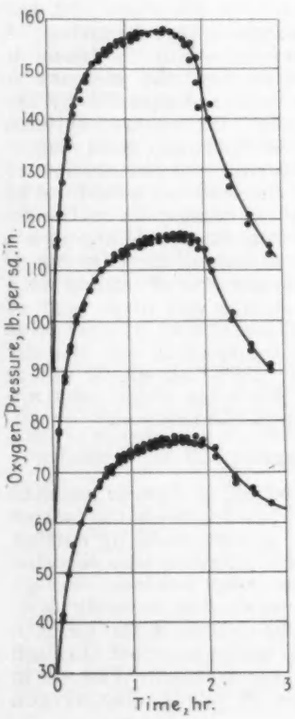
FIG. 6—GUM CONTENTS AT VARIOUS TIMES DURING THE ACCELERATED OXIDATION TEST FOR THREE OXYGEN PRESSURES

Various investigators have logically assumed that the drop in pressure at the end of the induction period was accompanied by gum formation and that, during the induction period, no gum was formed. To test the validity of this assumption, runs at three pressures were made with three gasolines of which the induction periods were known, and air-jet gum determinations were made at intervals of 2 hr. A plot of the data obtained for one gasoline is shown in Fig. 6, in which the arrows indicate the measured induction periods. Similar plots were obtained in the case of the two other gasolines. These plots suggested that little gum formation occurred until after the end of the induction period. To substantiate this evidence further, similar experiments were made with three gasolines at one pressure and the gum contents were measured at intervals of 15 min., starting approximately ¾ hr. before and continuing to ¾ hr. after the break in the time-pressure curve. A plot of gum content against time is shown in Fig. 7. These data verify the previous conclusion that there is not much gum formation during the induction period, while the amount of gum formed after the pressure begins to drop is large. This has also been confirmed by the data of Ramsay[8].

It should be pointed out that all of these gum values are higher than they would be if the gum content could be measured at the instant the bomb is removed from the bath. In practice, however, the bombs were placed in ice after removal from the oil bath and were not opened until about 20 min. later. While this cooling serves to slow down the oxidation reaction, there is unquestionably some gum formation during the cooling period. Although the air-jet determinations were made as soon as possible, some additional gum may have formed in this interval. Even with this qualification there appears to be a slight quantity of gum formation during the induction period, and hence the observed induction period represents a maximum value for the period of stability under the experimental conditions.

One point observed in connection with the gum formed during accelerated oxidation and illustrated in Fig. 6 is that the quantity of gum formed

[8] Paper presented at the September, 1931, meeting of the American Chemical Society.



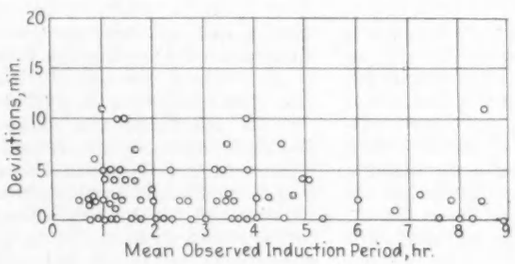


FIG. 4 (LEFT)—TYPICAL TIME-PRESSURE CURVES

FIG. 5 (ABOVE)—DEVIATION PLOT INDICATING THE PRECISION OF INDUCTION-PERIOD MEASUREMENTS

prior to the end of the induction period appears to become smaller as the pressure is decreased. Hence a measurement of the induction period at various pressures and extrapolation to an oxygen concentration equivalent to an air pressure of 1 atmosphere might give a truer indication of the period of stability at the temperature under consideration.

Preliminary experiments have shown that the break in the time-pressure curve is more abrupt with high than with low oxygen pressures, and that greater precision is obtained by working with oxygen pressures above 30 lb. per sq. in., although the induction period of interest is that corresponding to an air pressure of 1 atmosphere. Since extrapolation will be necessary to obtain this latter induction period, and since it is undesirable to be required to make measurements with various oxygen pressures at each temperature, a quantitative study of the effect of oxygen pressure was undertaken in the hope of establishing some quantitative relation for the effect of pressure on induction period.

Data were obtained on the induction periods of seven gasolines at several different temperatures and at initial oxygen pressures, at 0 deg. cent. (32 deg. fahr.),

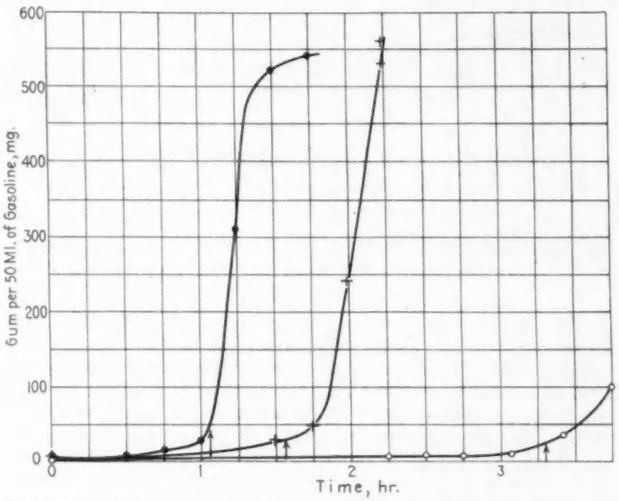


FIG. 7—GUM CONTENTS AT VARIOUS TIMES DURING THE ACCELERATED OXIDATION TEST FOR THREE GASOLINES

of 30, 60 and 90 lb. per sq. in. At each temperature the induction period was found to decrease with increase in pressure and, when the induction period was plotted against initial oxygen pressure, a straight line through the points reproduced the data within experimental error. A representative plot for one gasoline at four temperatures is shown in Fig. 8. The data for each of the gasolines were plotted in this way, and the lines were extrapolated to an air pressure of 1 atmosphere (3 lb. per sq. in. absolute oxygen pressure or —12 lb. per sq. in. gage pressure). The induction periods obtained experimentally and the extrapolated values for 100 lb. per sq. in. gage pressure and 3 lb. per sq. in. absolute pressure are given in Table 1.

Effect of Pressure

A comparison of the effect of pressure on the induction period indicated that the slope of each induction period-pressure line was dependent only upon the length of the induction period at any given pressure and independent of either the temperature or the particular gasoline employed. This is illustrated in Fig. 9, where all of the induction-period data at 100 lb. per sq. in. ini-

[9] Paper presented at the September, 1931, meeting of the American Chemical Society.

TABLE 1—INDUCTION-PERIOD DATA

Temperature		Induction Period at Stated Pressures, Lb. per Sq. In., Hr.				
Deg. Cent.	Deg. Fahr.	90	60	30	Air Pressure of 1 Atmosphere	100
		Fuel No. 1				
120	248	1.0	1.2	1.3	1.4	1.0
110	230	1.5	1.8	2.0	2.3	1.5
100	212	3.3	3.5	3.8	4.1	3.2
90	194	7.3	7.8	8.3	9.1	7.1
		Fuel No. 2				
110	230	0.7	0.8	0.9	1.0	0.8
100	212	1.1	1.3	1.3	1.5	1.1
90	194	1.7	1.8	2.0	2.2	1.6
		Fuel No. 3				
110	230	1.0	1.1	1.3	1.5	1.0
100	212	1.4	1.6	1.8	2.1	1.3
90	194	2.7	2.8	3.0	3.3	2.6
		Fuel No. 4				
120	248	1.0	1.2	1.2	1.4	1.0
110	230	1.6	1.7	1.8	2.1	1.5
100	212	3.5	3.8	4.1	4.4	3.4
		Fuel No. 5				
120	248	1.0	1.1	1.2	1.3	1.0
110	230	1.6	1.8	2.0	2.2	1.5
100	212	3.0	3.3	3.7	4.1	2.9
90	194	7.2	7.3	7.8	8.5	6.9
		Fuel No. 6				
110	230	1.2	1.3	1.3	1.5	1.1
100	212	2.0	2.3	2.3	2.7	1.9
90	194	4.5	4.7	4.9	5.4	4.3
		Fuel No. 7				
120	248	0.9	1.0	1.2	1.3	0.9
110	230	1.6	1.7	1.8	2.0	1.5
100	212	3.5	3.7	4.0	4.3	3.4
90	194	6.3	6.7	7.1	7.7	6.2

tial oxygen pressure, are plotted against the values at an air pressure of 1 atmosphere. For comparison, the data of Ramsay[9] are also included. The straight line represents the data within experimental error. The equation of the line in Fig. 9 is

$$I_{1\,atm.} = 1.38\, I_{100} \qquad (1)$$

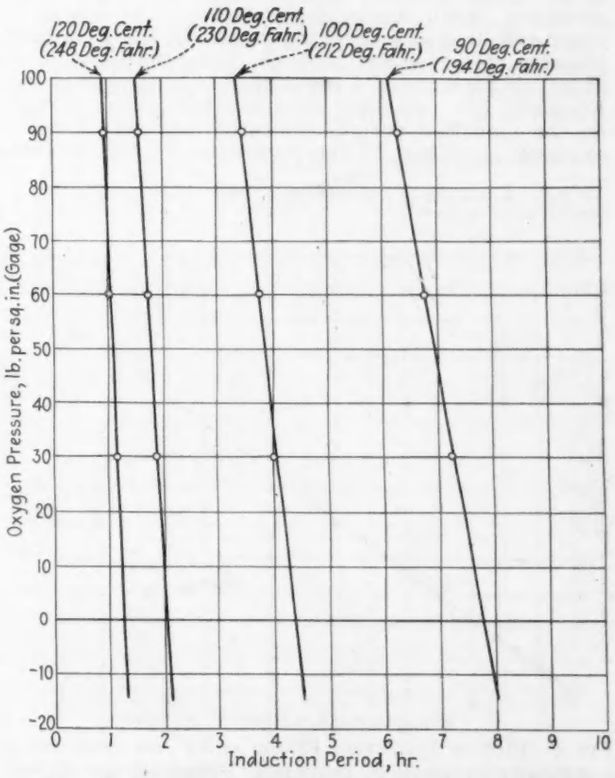


FIG. 8—EFFECT OF PRESSURE ON INDUCTION PERIOD

TABLE 2—ADDITIONAL INDUCTION-PERIOD DATA

Gasoline No.	Oxygen Pressure, Lb. per Sq. In.	Temperature		Induction Period, Hr.	
		Deg. Cent.	Deg. Fahr.	Observed	Air Pressure of 1 Atmosphere
8	110	110	230	1.3	1.8
		100	212	1.8	3.0
		90	194	3.4	6.2
9	90	110	230	1.0	1.3
		100	212	1.2	1.6
		90	194	1.8	2.4
10	90	110	230	1.1	1.5
		100	212	1.6	2.2
		90	194	3.4	4.5
11	110	120	248	1.1	1.5
		110	230	2.0	2.9
		100	212	3.4	4.9
		90	194	8.3	11.8
12	110	110	230	1.3	1.8
		100	212	2.2	3.1
		90	194	5.3	7.5

where I is used as a symbol for induction period expressed in hours and the constant 1.38 is identical with that proposed by Ramsay[10]. The general equation representing the relation between the induction period at any pressure and the value at an air pressure of 1 atmosphere, for the same temperature in both cases, can, therefore, be written

$$I_{1\,atm.} = \frac{154.6}{150 - 0.38\,P} I_P \qquad (2)$$

where P is the initial oxygen pressure in pounds per square inch gage. If Equation (2) is general, it is only necessary to make measurements at one convenient oxygen pressure and then compute the corresponding induction period for an air pressure of 1 atmosphere.

Effect of Temperature

The data in Table 1 show that the induction period at any given pressure changes markedly with the temperature. Additional evidence of this in the case of five other gasolines at several temperatures, but at only one pressure, is given in Table 2. The induction periods at an air pressure of 1 atmosphere are calculated from Equation (2). A study of the effect of temperature on the induction periods indicated that the change is exponential. Thus, if the logarithm of the induction period is plotted against the logarithm of the centigrade temperature, a straight line reproduces the plotted points within the experimental error. Fig. 10 is such a plot for two of the gasolines, the induction period used being that for an air pressure of 1 atmosphere.

The equations for the straight lines are of the form proposed by Ramsay[10], namely:

$$\log I_{1\,atm.} = a + b \log t \qquad (3)$$

where a and b are constants characteristic of each gasoline, $I_{1\,atm.}$ is the induction period in hours at an air pressure of 1 atmosphere, and t is the oil-bath temperature in degrees centigrade. The constants in this equation for each of the 12 gasolines are given in Table 3, together with the induction periods at 100, 40 and 30 deg. cent. (212, 104 and 86 deg. fahr.). The values for 40 and 30 deg. cent. are obtained by extrapolation of the induction period-temperature lines and correspond to the period of stability at storage temperatures as indicated by the experimental data and Equation (3).

It is noted that there is no general relation between the induction periods at 100 deg. cent. (212 deg. fahr.) and predicted length of stability in storage. There are

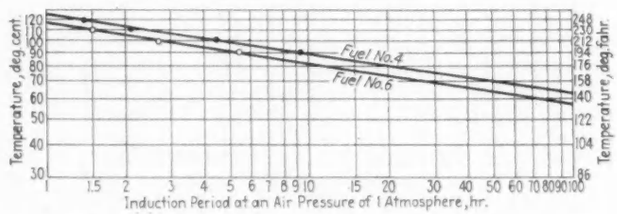


FIG. 10—LOGARITHMIC PLOT OF TEMPERATURE AGAINST INDUCTION PERIOD FOR TWO TYPICAL GASOLINES

three major reasons that may account for this fact. First, several of these gasolines had been stored for a considerable time and had apparently passed their period of stability so that their observed induction periods changed comparatively little with decreasing temperature. An illustration is given in Fig. 11, where the lower line is for fuel No. 9 and the upper line is for this fuel after it had been freshly distilled. Distillation decreased the air-jet gum content from 145 to 13 mg. per 100 ml. and increased the induction period at 100 deg. cent. (212 deg. fahr.) from 1.6 to 2.2 hr. The predicted time of stability was not increased proportionally, because the slopes of the two lines are very different. Thus the predicted period of stability at 40 deg. cent. (104 deg. fahr.) was increased from 31 hr. to 21 days; and at 30 deg. cent. (86 deg. fahr.) it was increased from 3.3 days to 113 days. However, even if the three unstable gasolines—Nos. 2, 3 and 9—are excluded, there still seems to be no general relation between induction period at 100 deg. cent. (212 deg. fahr.) and time of stability in storage.

A second reason for the lack of such a relation is that the induction periods of different gasolines change to a different extent with temperature, with the result that two gasolines may have the same induction period at 100 deg. cent. (212 deg. fahr.) and yet have considerably different values at other temperatures. On the other hand, two gasolines may have the same predicted period of stability in storage and have different induction periods at 100 deg. cent. (212 deg. fahr.). Therefore it is evident that the observed induction periods at any one temperature do not indicate the relative stability of gasolines under storage conditions. Hence it is necessary to obtain values at a sufficient number of temperatures to determine the change in stability with temperature to obtain a valid predicted stability period in storage.

[10] Paper presented at the September, 1931, meeting of the American Chemical Society.

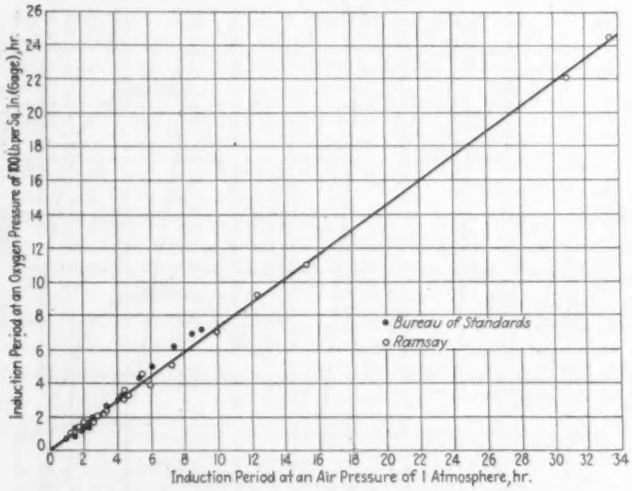

Induction Period at an Oxygen Pressure of 100 Lb. per Sq. In. (Gage), hr.
Induction Period at an Air Pressure of 1 Atmosphere, hr.
Bureau of Standards
Ramsay

FIG. 9—PLOT OF INDUCTION PERIOD AT AN AIR PRESSURE OF 1 ATMOSPHERE AGAINST INDUCTION PERIOD AT AN OXYGEN PRESSURE OF 100 LB. PER SQ. IN.

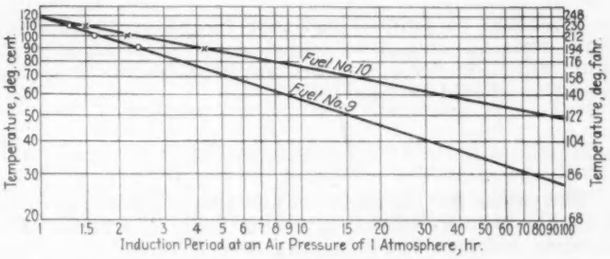


FIG. 11—LOGARITHMIC PLOT OF TEMPERATURE AGAINST INDUCTION PERIOD FOR AN UNSTABLE GASOLINE BEFORE AND AFTER DISTILLATION

A third reason is connected with the experimental procedure and will be discussed in the following sections of this paper.

Gasoline Temperature during Induction Period

The gasolines used in all of these experiments were at approximately 0 deg. cent. (32 deg. fahr.) when the bombs were introduced into the heated oil bath, and there was a period of time before they reached the temperature of the bath. Since the change in the observed induction period with temperature is large, it is evident that the observed induction period obtained by the method used is longer than the true isothermal induction period at the bath temperature.

TABLE 3—EFFECT OF TEMPERATURE ON INDUCTION PERIOD

Gasoline No.	a	b	Induction Period at Temperatures of: 100 Deg. Cent. (212 Deg. Fahr.)[a]	40 Deg. Cent. (104 Deg. Fahr.)[b]	30 Deg. Cent. (86 Deg. Fahr.)[b]
1	13.840	—6.60	4.1	77.0	519.0
2	7.377	—3.60	1.5	1.7	4.8
3	8.033	—3.85	2.1	3.0	9.2
4	13.630	—6.50	4.4	69.0	445.0
5	13.525	—6.45	4.1	65.0	415.0
6	13.340	—6.45	2.7	42.0	270.0
7	13.398	—6.40	4.3	58.0	366.0
8	13.099	—6.30	3.0	42.0	259.0
9	6.630	—3.20	1.6	1.3	3.3
10	12.077	—5.85	2.2	21.0	113.0
11	15.042	—7.15	4.9	162.0	1,260.0
12	15.615	—7.55	3.1	137.0	1,210.0

[a] Observed readings in hours.
[b] Calculated values in days.

Observed induction period has been defined in this paper as the interval between the time of the introduction of the bombs into the oil bath and the time at which the pressure begins to drop. The true induction period may be defined as the interval that would exist between the time of introduction into the bath and the time at which the pressure begins to drop if the gasoline reached the temperature of the bath immediately after the bomb was placed in it. In other words, it is the induction period that would be observed if the experiment were carried on isothermally at the bath temperature. It is not possible experimentally to fulfill this condition; but, if the rate of heating of the gasoline is known, it is possible to correct to the true induction period.

To measure the rate of heating of the gasoline, a copper-constantan thermocouple was placed approximately at the center of the liquid gasoline. This thermocouple was made by inserting 1/16-in. copper tubing through a hole made in the top of the bomb and soldering it in place. No. 28 insulated constantan wire was then inserted in the copper tubing and, after squeezing the lower end of the tube around the bared end of the constantan wire, the joint was soldered. Temperature measurements were made at regular intervals from the time the bombs were introduced into the oil bath until the temperature of the gasoline had reached that of the bath. The gasoline used in these experiments was a straight-run product, and hence possible catalytic effects by the thermocouple were negligible. Measurements were made at initial oxygen pressures of 90, 60 and 30 lb. per sq. in and at temperatures of 110, 100 and 90 deg. cent. (230, 212 and 194 deg. fahr.).

A typical series of time-temperature curves for a bath temperature of 100 deg. cent. (212 deg. fahr.) is shown in Fig. 12. It was found that the period of heating was very close to 90 min., irrespective of pressure or of bath temperature. The time of heating to various intermediate temperatures, the same number of degrees below that of the bath, did not vary to any appreciable extent with different bath temperatures but was, however, dependent upon the pressure. For example, the time required to heat the gasoline to a temperature of 10 deg. cent. (18 deg. fahr.) below that of the bath was, on the average, 29½ min. with an oxygen pressure of 90 lb. per sq. in., 35 min. with 60 lb. and 38 min. with 30 lb. Since the increase in time necessary to heat the gasoline to a temperature the same number of degrees below that of the bath at 60 lb. over that required at 90 lb. was twice as great as the increase from 60 to 30 lb., it is apparent that the rate of heating at an air pressure of 1 atmosphere would be very nearly the same as that at an oxygen pressure of 30 lb. per sq. in.

The foregoing information on rate of heating was obtained, for convenience, with a straight-run gasoline. To use this information for unstable gasolines, it is necessary to show that no heating occurs due to the oxidation reaction during the 90-min. period or, if the induction period is less than 90 min., prior to the end of the induction period. Considerable information has been obtained on this point, using gasolines of various degrees of stability, which clearly indicates that no heating due to the oxidation reaction occurs during the induction period but that there is a sudden rise in temperature as soon as the pressure begins to drop. In these experiments with unstable gasolines the thermocouple was inclosed in a glass sheath filled with a straight-run

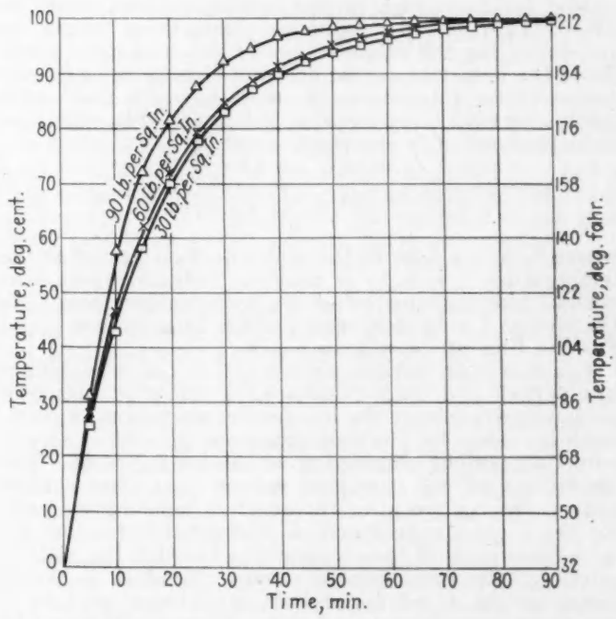


FIG. 12—TEMPERATURE RISE AFTER INSERTION OF THE BOMB IN THE BATH

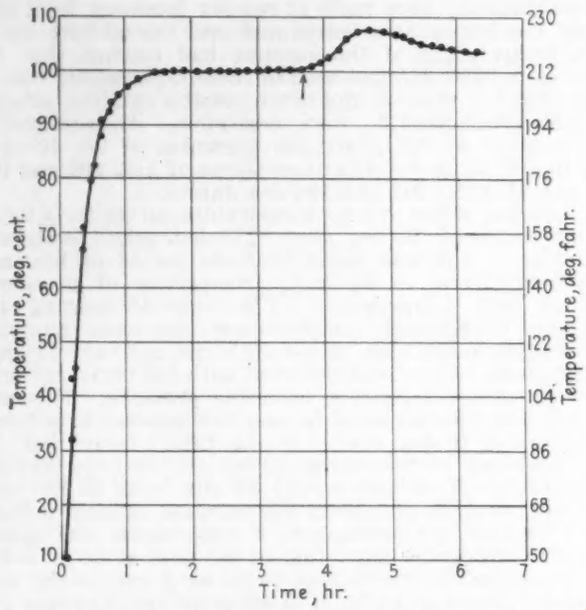


FIG. 13—TYPICAL TEMPERATURE-TIME CURVE ILLUSTRATING RISE IN TEMPERATURE WHEN OXIDATION COMMENCES

gasoline. The change in temperature due to the oxidation process and the absence of a heating effect due to oxidation prior to the end of the induction period are illustrated in Fig. 13.

True Induction Periods

The data obtained on rate of heating of the gasoline prior to the end of the induction period make possible a calculation of the true induction period at the bath temperature. Thus, if the bath temperature were 100 deg. cent. (212 deg. fahr.) and if 10 min. was required for the gasoline in the bomb to heat from 80 to 90 deg. cent. (176 to 194 deg. fahr.), then, as a first approximation, the correction to the induction period for this stage of the heating process would be $10 - [(I_{100}/I_{85}) \times 10]$. Similar corrections would be necessary for the other stages of the heating process. Since the induction period does not change linearly with temperature, integration is more accurate than summation by such large steps as indicated. Thus the true induction period is accurately given by the relation

$$I_{t_0} = (I_t - 1.5) + \int_0^{1.5} \frac{I_{t_0}}{I_{t_0} - \triangle t}\, d\theta \qquad (4)$$

where I_{t_0} is the true isothermal induction period at the temperature t, $I_{t_0} - \triangle_t$ is the true induction period at various temperatures below the bath temperature, I_t is the observed induction period at the temperature t and θ is the time of heating in hours.

Equation (4) implies knowledge of the true induction periods and, since these are the values sought, it is necessary to evaluate the integral by successive approximations, using for the first approximation the observed induction periods obtained from the log-log plots. The logarithms of the corrected values were then plotted against the reciprocal of the absolute temperature and, for the second approximation, corrected induction periods were read off the straight line through the plotted points. Two approximations were found to be sufficient, for the third approximation did not produce a change of more than 1 or 2 min. Since the integral is involved, analytical summation was employed in evaluating it.

It should be pointed out that Equation (4) applies only when the induction period is greater than 90 min. For induction periods less than 90 min. the following equation should be used:

$$I_{t_0} = \int_0^{I_t} \frac{I_{t_0}}{I_{t_0} - \triangle t}\, d\theta \qquad (5)$$

The values for the observed and true induction periods for the seven gasolines, given in Table 1, and the difference between the observed and true induction periods are given in Table 4. The average difference is 0.8 ± 0.1 hr. Therefore, for the apparatus and procedure used in these experiments, the true induction periods can be obtained by subtracting 0.8 hr. or 48 min. from the observed induction periods corresponding to an air pressure of 1 atmosphere.

On the basis of the general theory dealing with velocity of chemical reactions, it would be expected that the logarithm of the induction period for any given gaso-

TABLE 4—DEVIATIONS BETWEEN OBSERVED AND TRUE INDUCTION PERIODS

Fuel No.	Temperature, Deg. Cent.	Temperature, Deg. Fahr.	Induction Period at an Air Pressure of 1 Atmosphere, Hr. Observed	True	△
1	126	248	1.4	0.6	0.8
	110	230	2.3	1.5	0.8
	100	212	4.1	3.2	0.9
	90	194	9.1	8.2	0.9
2	110	230	1.0	0.4	0.6
	100	212	1.5	0.8	0.7
	90	194	2.2	1.4	0.8
3	110	230	1.5	0.8	0.7
	100	212	2.1	1.4	0.7
	90	194	3.3	2.6	0.7
4	120	248	1.4	0.7	0.7
	110	230	2.1	1.2	0.9
	100	212	4.4	3.5	0.9
	90	194	9.1	8.2	0.9
5	120	248	1.3	0.5	0.8
	110	230	2.2	1.3	0.9
	100	212	4.1	3.2	0.9
	90	194	8.5	7.6	0.9
6	110	230	1.5	0.6	0.9
	100	212	2.7	1.8	0.9
	90	194	5.4	4.5	0.9
7	120	248	1.3	0.6	0.7
	110	230	2.0	1.0	1.0
	100	212	4.3	3.5	0.8
	90	194	7.7	6.8	0.9

$\triangle = 0.8 \pm 0.1$ hr. $= 48 + 6$ min.

line would be a linear function of the reciprocal absolute temperature. Typical plots of this nature are shown in Fig. 14. The equations of the lines through the plotted points are of the form

$$\log I_o = A + (B/T) \qquad (6)$$

where I_o is the true induction period in hours and T is the temperature in absolute degrees centigrade. The data for each of the gasolines were plotted in this way and the constants for the equations of the lines through the points were obtained. Using these constants, the predicted periods of stability at 40 and 30 deg. centigrade (104 and 86 deg. fahr.) were calculated. These values and the true induction periods at 100 deg. cent. (212 deg. fahr.) are given in Table 5. The true induction periods for the last five gasolines were obtained by subtracting 0.8 from the values given in Table 2.

It is evident from Table 5 that there is no greater degree of correlation between the true induction period and the predicted stability at storage temperatures than between the observed induction period and the predicted stability at storage temperatures. This emphasizes the fact that it is necessary to conduct accelerated oxidation tests at more than one temperature.

Equation (6) has been restricted to induction periods

at an air pressure of 1 atmosphere. However, by use of Equation (2), it can be made directly applicable to induction-period data at any oxygen pressure. The general relation is

$$\log \left(\frac{154.6}{150 - 0.38\,P} I_p - 0.8\right) = A + \frac{B}{T} \qquad (7)$$

where I_p is the observed induction period at the pressure P, P is the oxygen pressure in pounds per square inch gage and the factor 0.8 applies to the present apparatus and would differ with the design of bomb.

Conclusions

The results of this investigation indicate several very definite things, as follows:

(1) The induction period of a gasoline at any given temperature changes with oxygen pressure in a regular manner which is independent of the particular temperature or gasoline employed. This makes it possible to restrict the experimental measurements to one pressure and, by a simple calculation, to evaluate the induction period corresponding to an air pressure of 1 atmosphere, which is the value of interest in connection with storage conditions.

(2) In any metal bomb in which a glass bottle is used to contain the gasoline during an accelerated oxidation experiment, the observed induction periods will be too long by an amount dependent upon the time required to bring the contents to the bath temperature. This time probably will not be less than 1 hr. and, with the design of bombs used in the present work, it was 1.5 hr. To obtain comparable results between different laboratories and to make the results of any real value in predicting stability in storage, it is necessary to correct to isothermal values for the induction periods. The correction in the present case amounted to 0.8 hr. and was found to be independent of the bath temperatures over the range investigated.

(3) The induction periods of different gasolines change to a different extent with temperature, so that measurement of the induction period at one temperature is not adequate for predicting gum stability in storage. For this purpose it is necessary to measure the induction periods at a sufficient number of temperatures to make possible an extrapolation to the probable storage temperature.

(4) As the temperature is lowered, the drop in pressure at the end of the induction period becomes less marked, so that there is a limiting temperature below which it is not practicable to go with the type of pressure-measuring equipment used in the present investigation. This restriction limits the temperature over which data can be obtained and makes uncertain the extrapolated values at storage temperatures. Thus, while the present work indicates that the effect of temperature may be different for different gasolines, it does not suffice for giving anything more than approximate values for the predicted stability in storage.

TABLE 5—PREDICTED PERIODS OF STABILITY IN STORAGE

Fuel No.	True Induction Period at 100 Deg. Cent. (212 Deg. Fahr.) Hr.	Calculated Induction Period, Months From Log-Log Equation at 40 Deg. Cent. (104 Deg. Fahr.)	Calculated Induction Period, Months From Log-Log Equation at 30 Deg. Cent. (86 Deg. Fahr.)	Calculated Induction Period, Months From Log — (1/T) Equation at 40 Deg. Cent. (104 Deg. Fahr.)	Calculated Induction Period, Months From Log — (1/T) Equation at 30 Deg. Cent. (86 Deg. Fahr.)
1	3.2	2.6	17.3	2.8	8.1
2	0.8	0.06	0.2	0.1	0.3
3	1.4	0.1	0.3	0.1	0.3
4	3.5	2.3	15.0	2.9	10.9
5	3.2	2.2	13.8	2.2	8.0
6	1.8	1.4	9.0	2.1	8.7
7	3.5	1.9	12.2	1.5	5.2
8	2.2	1.4	8.6	1.6	5.9
9	0.8	0.04	0.1	0.1	0.3
10	1.4	0.7	3.8	1.1	3.9
11	4.1	5.4	42.0	3.8	14.1
12	2.3	4.6	40.0	4.1	17.7

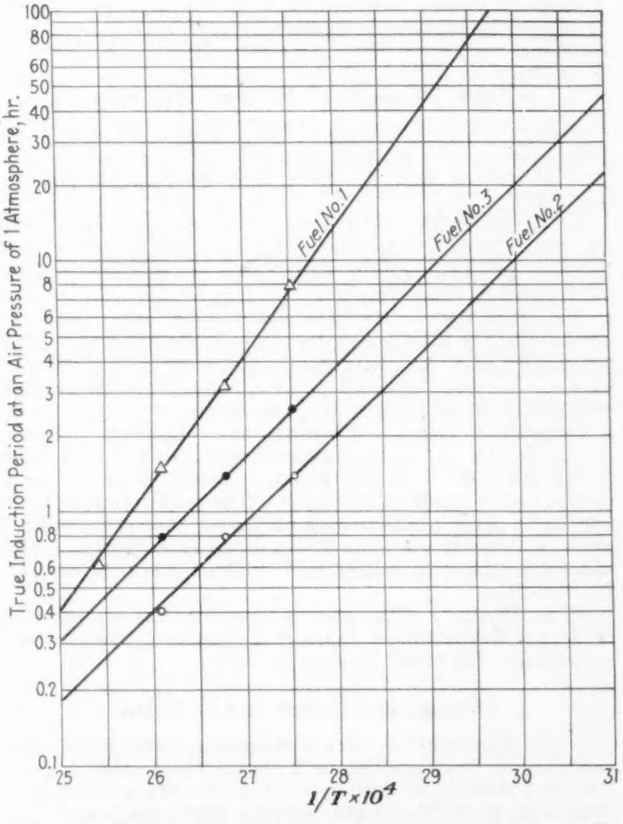


FIG. 14—PLOT OF TRUE INDUCTION PERIOD AGAINST THE RECIPROCAL ABSOLUTE TEMPERATURE

Further study of the accelerated oxidation method is planned to make a comparison between the predicted values for gum stability and the results of storage tests. However, it is considered that, prior to investigating this phase of the problem, it would be advisable to extend the study of the effect of temperature to reduce the uncertainty in the predicted induction periods at storage temperatures due to the length of the extrapolation. Experiments have shown that the rate of decrease in pressure at the end of the induction period is small at low temperatures; therefore the accuracy of the induction-period data is limited by the precision of the pressure-indicating device used in these experiments.

There are two methods that might be employed to remove this difficulty; first, a more precise means of measuring pressures might be used to determine smaller drops in pressure than is now possible; second, samples of gasoline might be maintained in the laboratory at constant temperatures from 50 to 70 deg. cent. (122 to 158 deg. fahr.) and the gum contents measured at various time intervals. The length of time the gasoline could be kept at any temperature prior to the beginning of rapid gum formation would be an indication of the induction period at that temperature. Either of these two methods would permit an extension of the range over which the induction period could be measured conveniently, and hence a more accurate prediction of stability in storage. After information of this nature has been obtained, comparison with the results of storage tests is desirable as a final check on the significance of the accelerated oxidation method.

THE DISCUSSION

CHAIRMAN J. B. HILL[11]:—We are much indebted to Miss Aldrich for bringing before us this subject of gum formation or resin formation in the rear tank; it is a vital problem with all of us. Our company has had considerable trouble with some automobile dealers who put a gallon or two of gasoline into the tank and let the car stand on the floor; sometimes, in certain cases, for six months or a year before it is sold. When the car is to be driven, it cannot be driven because the fuel lines are plugged up. The dealers tell us that it is the fault of our gasoline and that, if they use another refining company's gasoline, they have no such trouble. But we find, after consulting the other specified refining company, that the dealers tell the same story about its gasoline, saying that if our company's gasoline is used, no such trouble will occur. It is a rather serious problem; one which can be rather easily remedied by the automobile manufacturers.

Necessity for Two Tests Doubted

ROBERT E. WILSON[12]:—Judging from the paper, accurate prediction of behavor in storage apparently would necessitate measuring the induction period at two different temperatures; however, I question whether the degree of divergence shown between two different gasolines is enough to justify the complication of measuring at two different temperatures, because variations in storage conditions are enormously greater than any variations between two gasolines, at least to the extent indicated in the paper. Not only do we have wide variations in the temperatures of storage, which fluctuate up and down and are unpredictable over a given time, but we also have wide variations in the effective oxygen concentration. For example, if we store at the same temperature a large volume of gasoline in a large tank it does not deteriorate so rapidly as a smaller volume of gasoline, such as 1 gal. in the rear tank of an automobile. Therefore, I still feel that the induction period is about as good an indication as we need without going into the complication of two tests at different temperatures. Incidentally, I rather doubt the validity of the wide extrapolations to low temperatures on the basis of the data available.

Concerning gum formation, what we call gum and what we call resin depend entirely on our definitions. Do you find any residue deposited, after standing, from gasoline which has not already formed some gum that would become evident by making the air-jet test?

O. C. BRIDGEMAN[13]:—Miss Aldrich emphasized that the log-log plot was not a correct method for extrapolation, due to the fact that some time was required to heat the gasoline in the bomb up to the bath temperature after the bomb was immersed in it. Correcting for this time of heating makes possible a plot on a logarithmic reciprocal temperature scale. That is the sort of plot which we would expect on the basis of the theory for reaction velocities. On such a plot whether we use absolute temperature centigrade or absolute temperature fahrenheit would make no difference. On a log-log plot, several absurdities come in; for instance, extrapolation to 0 deg. cent. (32 deg. fahr.) is meaningless. There seems to be no reason why a logarithmic reciprocal temperature plot should not be satisfactory for predicting within reasonable accuracy the stability in storage. It does require measurements over a moderately wide temperature range. Differences are found in the slopes of the induction-period lines, even in some cases between gasolines that have the same induction period. Thus, of two gasolines having the same induction period at 100 deg. cent. (212 deg. fahr), one may show a predicted stability in storage of three months and the other a predicted value of two years. Evidently we are not very much worried if we can predict within a month, but a difference between three months and two years is considerable.

MR. WILSON:—You did not make any storage tests to prove that. You only assumed that those lines would continue straight down to some low temperature and attain that result at that temperature. Actually, the difference between results at 110 and 195 deg. cent. (230 and 383 deg. fahr.) was not found in the range covered, was it?

MR. BRIDGEMAN:—No measurements were made above 120 deg. cent. (248 deg. fahr.); but, over the range of temperature investigated experimentally, marked differences in slope of the induction-period lines were found. Our storage tests have been limited, but they do check out to a reasonable extent with the predictions.

MR. WILSON:—What about that resin question?

MR. BRIDGEMAN:—I do not know that I have any information to answer that. We have done very little work on it. In my opinion any gasoline, whether it contains gum or not, but which has an induction period of less than about 20 hr. at 100 deg. cent. (212 deg. fahr.) and a pressure of 100 lb. per sq. in., will deposit resin in contact with zinc chloride. I am sure that resin deposition is independent of whether the gasoline has any gum by the air-jet method or not.

Gum Deposits in Stored-Car Tanks

HARRY STROHM[14]:—Could gum deposits form in the fuel systems of cars that have been in storage for only one or two weeks, to the extent of causing starting trouble?

E. W. ALDRICH:—We have little information on that. It probably is a question of how much zinc chloride is present in the flux. In some cases enough resin might be formed to cause trouble.

MR. STROHM:—My experience with cars that had probably only a gallon or two of gasoline put into them originally and that have been in storage for a week or two is that they are apt to give some starting trouble. Could this be attributed to gum deposit or evaporation?

CHAIRMAN HILL:—I think the starting difficulty would be due to weathering rather than to gum trouble.

MR. WILSON:—The evaporation would be proportional to the vapor space in the tank. The vapor expands and contracts with temperature changes; therefore, with a small volume of gasoline and a large vapor space, a considerable quantity might be lost in a warm place even in a week.

A. L. BEALL[15]:—The shortest period that we know of in actual formation of resin in a tank or system, where we checked the time, was three weeks.

Definitions of Gum and of Resin

J. P. STEWART[16]:—Mr. Bridgeman mentioned that resin could be deposited in a fuel system from a gasoline that showed no gum content on the evaporation test. How does he differentiate between gum and resin?

MR. BRIDGEMAN:—The subject of nomenclature is involved. In a paper given some time ago, gum was de-

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[12] M.S.A.E.—Director, Standard Oil Co. (Indiana), Chicago.

[13] S.M.S.A.E.—Chief of friction and lubrication section, Bureau of Standards, City of Washington.

[14] M.S.A.E.—Sales engineer, Bendix Stromberg Carburetor Co., Detroit.

[15] M.S.A.E.—Mechanical engineer, refined oil department, Vacuum Oil Co., Inc., New York City.

[16] M.S.A.E.—Head of automotive division, Vacuum Oil Co., Inc., Paulsboro, N. J.

fined as a residue that is left on the evaporation of gasoline. That covers many things and avoids the difficulty on nomenclature to some extent. I think the only distinction we can make is purely empirical; namely, that one separates from the liquid phase and the other is formed by evaporation. Although I have not proved it, I think that a difference in the mechanism exists in the two cases. I think that gum formation is largely concerned with oxidation and is followed by a polymerization; whereas, resin formation is more of a polymerization process caused by catalytic materials. To define what resin really is and what gum really is, is very difficult, particularly since both terms frequently are used synonymously and perhaps incorrectly.

L. F. BURGER[17]:—How serious is this subject of resin and gum? Is it something for us to worry about?

MR. BRIDGEMAN:—In a certain small town they had no fires for six months. Then a fire occurred and, when they attempted to start the fire engine, it would not start. The copper fuel tanks were responsible for filling the whole system up with resin. The matter is serious in some cases, although it probably could be avoided. It is possibly more a question of care in cleaning up the fuel system before the car is sent out, and then taking care not to leave gasoline standing in contact with the copper fuel lines for periods of more than a few weeks.

Advance Research Work Desirable

T. C. SMITH[18]:—In fleet operation, I have been watching this gum proposition very carefully. My impression, based on experience, is that the oil people, so far as gum is concerned, are making better gasoline than they are getting credit for. Frankly, so far as I can see, the situation is not bad.

MR. BRIDGEMAN:—In any research work—specifically referring to the automotive and the petroleum industries—the thing to do is to get the information on a problem before the problem arises. We know fairly well that not much gum trouble exists at present, but the possibility is that more and more will occur. If we can get the information in advance, that situation can be taken care of without considerable trouble being experienced on the part of both the petroleum and the automotive industries. That is the main reason back of pushing the investigation of this problem at present.

MR. SMITH:—I did not mean that I thought no attention should be given to the gum problem; later someone will begin making gasoline that has too much gum in it. We had better find out about it before rather than afterward.

Gasoline Removal from Stored-Car Tanks

T. A. BOYD[19]:—An instance was mentioned of a car that had a small quantity of gasoline in the tank and was left idle for a short period. Material that gummed up the fuel system was deposited or separated from the gasoline. The suggestion was made that this could be avoided by proper means, but those means were not specified.

CHAIRMAN HILL:—In the particular cars that we had in mind, I am sure that the rear tanks had been soldered by using a zinc-chloride flux, and that enough flux remained within the tank to cause polymerization and hence cause resin formation. I believe that, in most cars, this practice is now eliminated.

MR. BOYD:—I had in mind that you suggested the trouble could be avoided by taking care to remove the gasoline from the fuel system when cars are in storage. How long a period have you in mind after which removal is necessary?

CHAIRMAN HILL:—I did not suggest gasoline removal; but the idea is excellent. It is generally advised that gasoline be removed from motorboats that are laid up during the winter.

Resin Cited as Trouble Breeder

C. W. MCKINLEY[20]:—Our trouble is not with gum; it is with resin. It is particularly noted in the difference between cars that are shipped from the factory and cars that are driven away. The latter going into the same territory and using the same gasoline may never give any trouble. Cars that are shipped with a small quantity of gasoline left in the tank give trouble sometimes, but not always. Invariably, when trouble occurs, if the tank is removed and the gasoline thoroughly washed out, the trouble never recurs after new gasoline is put in. Most of these cases occur where zinc-chloride flux has been used. At present piecework prices, the mechanic who uses the flux is not careful about how he gets it in. If all gasoline tanks were thoroughly washed out with either steam or hot water, we believe that 90 per cent of the resin-formation trouble would disappear. The remainder of gasoline stored in cars that are for sale would not constitute a very serious matter. But, with the majority of tanks, the excess of zinc-chloride flux is so great that trouble would be caused if, say, 2 gal. of gasoline should stand in a tank for three weeks.

CHAIRMAN HILL:—I think that three weeks is a fairly good estimate.

[17] M.S.A.E.—Chief engineer, International Harvester Co., Chicago.

[18] M.S.A.E.—Engineer, automotive equipment and construction apparatus, American Telephone & Telegraph Co., New York City.

[19] M.S.A.E.—Head of fuel section, General Motors Corp. Research Laboratories, Detroit.

[20] M.S.A.E.—Chief engineer, A. C. Spark Plug Co., Flint, Mich.

Noise and Heat Control in the Automobile Body

By C. L. Humphrey[1]

Annual Meeting Paper

INSULATING of automobile bodies against noise and heat has been made more complicated by the trend toward lower and more compact bodies and larger and more powerful engines, as more noise and heat are created and must be excluded from the body. Development of the all-steel body also has presented a new problem that calls for different treatment than the composite steel and wood body.

Elimination of noise and heat from the body is the mutual problem of the chassis and the body engineers and must be attacked jointly, correction of the trouble being made at the most logical and practical places. Much successful work has been done in the last few years to eliminate noise and heat, but much more can be accomplished by further concentrated effort.

After listing the more objectionable chassis noises which have received most attention, the author considers the remaining noise and the heat against which the body must be insulated. He then proceeds to a consideration of available insulating materials and adhesives that are suitable for the purpose, describes testing methods and gives details of application to and treatment of different parts of the body.

In conclusion, probable future developments in body insulation are forecast.

A discusser mentions the direct application of acoustical knowledge to treatment of the problem, saying that engine vibrations are transmitted to the chassis frame and are amplified by vibration of the body panels at frequencies of the same order as the primary vibrations from the power source or driving force and that low frequencies are the more difficult to control. In reply, the author states his belief that low-frequency vibration is the most desirable and that reducing the period of the panels below the range of frequency of the frame is not necessary.

COMPLICATIONS are being added to the problem of noise and heat insulation in automobile bodies by the present trend of automobile design. The cars are lower and more compact, which means less space for the circulation of air. The engine size and output have been increased, resulting in more heat and more intake, exhaust and general engine noise. Frontal area of cars has been reduced, which, combined with the larger engines, calls for more efficient cooling fans. General car performance has been improved and top speeds increased, necessitating tires that are safer and that provide more traction. Increased speed and acceleration put additional stresses on the rear axle, transmission and all other moving parts of the chassis and on the body. All of these conditions, which result in more noise and heat, must be met and overcome.

The demand for safety and stability in body construction and the development of the all-steel body have presented an angle of the body-insulation problem that is new and that calls for different treatment than the composite body. Both the body and the chassis engineers have sensed the problems presented by this new trend of design and a surprising volume of work has been done in the last few years to eliminate heat and noise. Every make of car today has a certain amount of insulation, which is more complete in some than in others. The results have been effective and gratifying, but I think they are only an indication of what can and should be done with further concentrated effort.

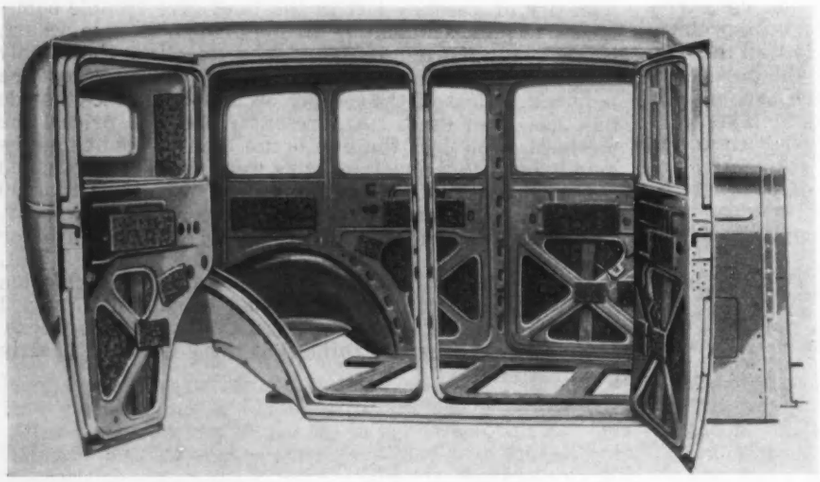

FIG. 1—APPLICATION OF INSULATION TO INSIDE OF PANELS OF AN ALL-STEEL BODY AS PRACTISED TODAY

The Material Used Is ⅜-In-Thick Jute Secured to the Panels with an Adhesive Such as an Asphalt Emulsion. The Front of the Dash, the Toe and Floor-Boards, the Seat Pans or the Whole Underbody Are also Covered with Absorbent Material

Quietness, elimination of heat and smoothness of operation must be placed on an equal basis with stability and performance for consideration by the designers of all the units that make up the finished car. The elimination of heat and noise in the body cannot justly be regarded as solely the responsibility of the body engineers, since the chassis is the source of virtually all the noise and heat. The problem must be attacked jointly, and the correction made in the most logical and practical place.

Considering first the chassis problems and how effectively they have been met will reveal the remaining noises and heat against which the body must be insulated. Chassis disturbances that are most objectionable and that have received the most attention are

Intake roar
Carbureter hiss
Exhaust noise
Fan noise
Tire noise
Torsional vibration
Road noise
Transmission noise
Miscellaneous

[1] Engineering Division, Chrysler Corp., Detroit.

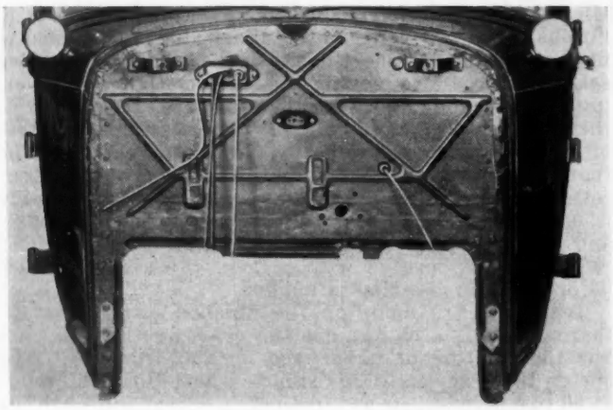

FIG. 2—PREPARATION OF THE COWL DASH FOR INSULATING

As Few Holes as Possible Are Made in the Dash and Floor-Board, and Instrument Wires Are Run through Rubber Blocks That Seal the Holes against Passage of Heat. A Dash Liner of Insulating Material, Prepared as Shown in Fig. 3, Is Then Applied

General Method of Body Insulation

With the major chassis noises eliminated or damped at their source, the remaining noise against which the body must be insulated is one that is very general in tone. It is a blending of all minor noises, with no marked increases in intensity. Each noise cannot be considered separately, as in the chassis. Together with this general sound must be considered the heat. Any type of insulation must be both heat and sound resisting. The most general method of body insulation used today is the covering of the inside of the body panels, as in Fig. 1. This insulation varies in thickness throughout the body. The toe and floor-boards and the seat pans, or the whole under body, also are covered with flexible material.

The first consideration in insulating a body is the materials that are available and how well they will serve the purpose. Fortunately, reliable test results on the thermal conductivity and insulating value of sheet materials as sold are available through the Bureau of Standards.

These tests usually are conducted by the hot-plate method, which gives as accurate results as any available testing means. This test is made with a metal plate heated by electric elements. Usually the plate is 12 in. square and has a 10-in. testing portion. The outside portion of the plate, called the guard ring, is separated from the testing surface by an air space and is heated separately so that the heat escaping at the edges of the material is compensated for by the flow of heat from the guard ring to the testing portion of the plate, thus maintaining a constant potential. The material to be tested is placed on both sides of the hot plate, and the other sides of the material are covered with steel plates cooled by a flow of water. The hot plate is brought to a constant temperature, the quantity of heat passing through the material is measured by copper-constantan thermocouples for 1-in. thickness, 1-sq.-ft. area, and 1-deg. difference in temperature between the hot and the cold plate, and the coefficient is thus obtained.

Water-absorption tests also should be run. This usually is done by immersing a given piece of insulating material in water for a definite time, weighing before and after soaking.

The sound-deadening properties of various materials can be tested by filling a window between two rooms with the material, operating a source of sound in one room and taking intensity measurements in the other room with a galvanometer having a period of 10 to 15 sec.

Bend and tensile tests also should be made on the stiff, fibrous boards if the material is to be formed. Insulite, Masonite and Celotex are effective as stiff, fibrous materials. Jute and felt or jute with a cardboard facing prove very effective as soft, flexible materials. For use throughout the body, jute with a cardboard facing is more desirable than jute and felt, as it not only leaves a clean-looking job but the cardboard serves as a reverberating surface for sounds penetrating the felt.

Means of Attaching Material to Panels

The next item to consider in insulating the body is the means of attaching the material to the panels. For the front of the dash the most practical method is to use fasteners, rivets or a similar means, because of assembling conditions. Throughout the rest of the body, adhesives of various types are used. The adhesive used must be one that is odorless and easy to apply, that will remain soft, withstand heat and cold and is not affected by alkaline materials on the body. An important quality to consider is that the adhesive will not dry out, crack and drop off, as insulation, to be effective, must be in contact with the complete panel at all times. The adhesive should also be thick enough so that it will not take up too much of the insulating material. Asphalt emulsions have proved to be satisfactory and practical for this purpose. Future developments in adhesives probably will be toward one that is easier to apply and

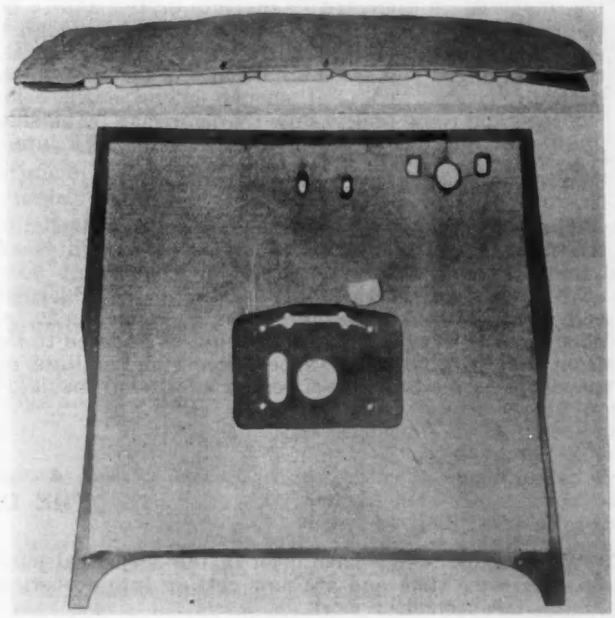

FIG. 3 (ABOVE)—DASH LINER FOR COWL INSULATION

This Consists of ¾-In.-Thick Jute or Felt Backed by a Stiff, Fibrous Board ½ In. Thick and Covered with a Facing Board. The Stiff Board Is Cemented to the Jute or Felt and to the Facing Board. The Assembly Usually Is Fastened to the Dash with Rivets

FIG. 4 (BELOW)—INSULATION COVERING FOR FRONT FLOOR-BOARD

A Sheet of Jute ⅜ In. Thick, Is Covered with Carpet or a Rubber Mat, to Which It Is Secured with an Adhesive. The Toe-Board Requires Additional Insulation, As It Is Exposed to Considerable Exhaust Heat. A Stiff, Fibrous Board Is Riveted to the Under Side of the Covering and Formed To Fit the Toe-Board

handle in the shop. Rubber-base adhesives appear to have possibilities.

With the insulating materials and adhesives available, the next questions are where to put the insulation and what kind and how much to use in each place. We should also keep in mind that the body is being insulated against heat, chassis noise and panel rumble and is to be generally deadened. The only present effective means of determining whether this has been accomplished is by actual road test with various installations. It can be partly predetermined by taking temperature readings at various points throughout the body and in front of the cowl. An important consideration is that, to be fully effective, insulation must be complete. To partly insulate a body, a thin covering over all sections would be much more effective than a thick coating in the worst place and none throughout the rest of the body.

Another important point is that the fewest holes possible should be put through the dash and floor-boards and that every hole should be properly sealed with a rubber grommet or its equivalent. The latest development along this line is the use of only one or two holes in the cowl for the instrument wires and tubes, which are run through a rubber block fastened in the cowl as shown in Fig. 2. All joints in the insulation should overlap and be fastened together. Starting with the cowl, which is the worst place in the body for heat and noise transmission, a very effective insulation has been a dash liner made of jute or felt ¾ in. thick backed by a stiff, fibrous board ½ in. thick, as in Fig. 3, this in turn being covered with a facing board. The stiff board should be cemented to the jute or felt and to the facing board. The felt pad should be large enough to extend around the sides of the cowl and overlap the cowl covering. The assembly usually is fastened to the dash by rivets. The felt should extend down below the cowl and come underneath the floor mat. The sides and top of the cowl are covered with ⅜-in.-thick jute.

Treatment of Toe and Floor-Boards

The rest of the body is completely covered, including the floor, with jute ⅜ in. thick, all of which is secured to the panels with adhesive. The front floor-board is covered with jute of the same thickness and then covered with carpet or a rubber mat, as illustrated in Fig. 4. The felt should be adhered to the front mat to give better appearance and facilitate removal. The toe-board requires an additional insulator, since it is exposed to considerable exhaust heat. A stiff, fibrous board is riveted to the under side and formed to fit the toe-board. Sheet-metal floor-boards can be used satisfactorily by employing the same method and covering the under side with insulation board. Lowering of the cars has also made necessary the placing of a sheet of asbestos over the muffler to eliminate heat from the rear compartment of the body. A portion of this floor covering usually can be omitted when a composite body is used. The seals around the clutch and brake pedals and gearshift lever should be very tight.

The roof is covered with a ¼-in.-thick layer of felt before the top covering is applied.

Test runs are made on the finished body with one thermometer placed against the cowl, another just below the instrument panel, one on the front seat and one on the rear seat. Our standard test run is 20 miles at 50 m.p.h., with the car completely closed and readings taken at the beginning and end of each run. With an outside air temperature of 70 to 75 deg. fahr., the temperature increase in any part of the body should not exceed 7½ per cent. Comparative tests must be made as nearly as possible under the same weather conditions.

Probable Trend of Development

The trend of development in body insulation probably will be toward a more effective and complete insulation that is easily applied and with less expense. The importance of small holes and exposed panels is being recognized, and cleaning up the inside of the body as much as possible and making a careful acoustical analysis of each body is desirable. Insulation as now applied is in too many pieces; a material that can be sprayed over the entire inner surface of the body and that will give results comparable with those of felt does not seem to be beyond probability.

Another line of development that should have more consideration is insulation of the roof and upper panels against heat and cold. In the underbody, one-piece sheet-metal front floor-boards look like the next move. This would certainly be in the direction of simplicity, more pleasing appearance and reduction in cost. More complete insulation of the body from the chassis does not seem to be out of line. This probably will be accomplished by eliminating the body shims and mounting the body on rubber-insulated supports. Heat deflectors probably will be more generally used in the engine compartment to direct the heat away from the dash and cowl.

THE DISCUSSION

W. A. JACK[*]:—We have been in the acoustical business for some time and are now getting into acoustical studies in automotive work.

Mr. Humphrey mentioned what we regard as primary and secondary sources of noise, although he did not refer to it in that way. We regard engine vibration as the primary source. When a primary disturbance, such as engine vibration, gets into the frame, it is transmitted along the frame and appears in its worst form as a secondary disturbance in the body panels. One form of attack is to keep down the size of the body panel. Another is to keep the panel from vibrating or to load it in such a way that it vibrates at a different frequency.

To do all we can to localize the primary sources is very important, because, once the panel starts vibrating at low frequency, it is difficult to stop.

Placing of deadening material against the panel functions primarily by loading the panel so that the natural vibration is of a low frequency, and as far as possible below the frequency of the primary source causing the vibration, that is, the engine.

The automobile body-panel has its natural vibration period, but it usually is different from the vibrating period in the frame. At certain speeds some panels vibrate more than others do, because the vibrating period in the frame changes with the speed, and when the natural frequency of the panel coincides with that of the frame, the panel vibrates excessively. When the panel is loaded by attaching sound-absorbing material, its frequency and its response are changed.

(*Concluded on p.* 214)

[*] Jun.S.A.E.—Chief engineer, acoustic division, Burgess Battery Co., Madison, Wis.

Responsibility of Manufacturing Management

By Gordon Lefebvre[1]

Annual Meeting Paper

ONE of the most important phases of industrial management is the place in industry of minor executives such as foremen, sub-foremen, time-study men, tool-designers and those holding similar positions, and the treatment and handling of these executives through the varied ups and downs of the business cycle. Undoubtedly, this subject has been given all too little intelligent study and attention by the average industrial management. A by-word in the Army is to the effect that battles are won by the non-commissioned officers. These men are the ones who interpret and execute the orders of the high commands, who make or break the members of the Army unit. In the same manner do our minor executives in industry perform their functions for us. What a corporation achieves is a consummation of the achievement of the individuals comprising it. The strength and characteristics of a company are a composite of the strength and characteristics of its many employes. If the policies of our institution are to be interpreted wisely to the rank and file of the army of workers and the plans of this company be intelligently and faithfully carried out, obviously these non-commissioned officers or sub-executives must be able and willing to perform these functions. I would venture to say that the rate of progress made by any business institution is directly in proportion to the effectiveness of this particular personnel.

For selfish reasons then, if for no other, we should be well assured that these sub-executives have been selected with the most meticulous care, have received an intelligent and diligent training and education and enjoy a fair method of compensation.

One of the most important phases of industrial management is the place of minor executives in industry.

The average foreman in an industrial plant represents an investment of approximately $5,000.

Careful selection, intelligent training and equitable compensation will produce an efficient sub-executive.

Cost of changes in material can be definitely foretold, but this is not true of personnel changes.

Management must realize that a sub-executive represents as definite a capital investment as money expended for new equipment.

Effectiveness of wage plans depends largely upon the spirit in which the men carry out their instructions.

Telling a sub-executive why a job should be done in a certain way always pays.

Closer cooperation between the engineering department and the shop is important.

Careful Selection Is Important

My experience has been that the average foreman in the average industrial plant represents an investment in actual dollars and cents to that company of about $5,000. Surely, then, we should give to the selection of that individual at least as much thought and effort as to the selection of a piece of machine-tool equipment representing a like outlay of capital. Yet how many companies have any intelligent or methodical means of selection? In nine cases out of ten these appointments are made in a haphazard way; and the fitness of the individual involved is passed on by only one superior, who may or may not be capable of such determination and who may or may not be influenced by personal motives.

How much more intelligent our choice would be and how much more effective the results, if we would exert ourselves to the point of instituting a logical system of selection through the use of a simple form of rating for all prospective sub-executives. I do not hold that a man's character and capabilities can be measured mathematically and exactly and set down in black and white. However, we surely have a better foundation on which to base our solution if we keep a running record of the performance of these prospects. Furthermore, their history or performance records, as they may be called, should not be built up by one superior but should reflect the composite opinions of several individuals with respect to that prospect. Moreover, I believe that no sub-foreman, foreman or minor executive of any sort should be hired or promoted without at least a short interview with one of the ranking officers of the institution, preferably the general manager or president. While this officer should not be burdened with the selection, I believe that these appointments are important enough to warrant the expenditure of a few minutes' time on the part of such executive. The candidate could be told in a few words the aims and aspirations of the company and the part he may play as a member of the organization. Such a personal interview will have a beneficial effect upon the morale of an individual. When an officer is appointed in the Army, his commission is signed by the President of the United States, which gives the duties special dignity.

Before leaving the subject of selection, I would like to emphasize one point strongly. We should be diligent not only in the matter of quality but likewise with regard to quantity. Most industrial institutions, certainly up until the last two years, have been heavily overmanned with sub-executives. Things have been too easy for us in the last decade, industrially speaking, and we have given way to a natural human tendency to laziness. When added problems and responsibilities have arisen, we have put in more help, rather than tighten our own belts and forego that weekly afternoon of golf. Part of the silver lining to the present cloak of depression may be made up of the fact that many of us have learned how to work again. Certainly, if we exercise proper care and thought in our selection of sub-executives, giving due regard to both quality and quantity, we shall have less of a problem of disposition

[1] Consulting engineer, Detroit.

in times of low production. The last pancake always causes the indigestion.

The second essential in the handling of our non-commissioned group is a system of training and education. At the time of their appointment, most of these sub-executives have had no previous experience in the handling of men, in the application of wage-payment systems, in the administration of budget-control and the myriad other problems that they are at once called upon to face. The sub-executive's immediate superior has neither the time nor perhaps the inclination to help him to any great extent. Surely we cannot logically expect the grace of God to descend upon the man and imbue him with the knowledge necessary for the proper functioning of his job.

We are initiating an investment in this individual which in due time will represent a substantial outlay of capital. Certainly our best efforts should be made to qualify him so that he can function intelligently. I believe I can truthfully state that this is not being done in the usual industrial plant today. My amazing experience has been to go into plants that were headed by executives of the very highest caliber and, in connection with the foremen, to discover the most appalling ignorance of the fundamental essentials of their job. When a foreman does not understand, for instance, the operation of the wage-payment system under which he is working, how can we expect him to keep his men in a happy frame of mind or to feel that way himself? Yet I can assure you that I have stated the case mildly.

By all means, every sub-executive should be given a course of training. Most of them will be found avid for such education. This training may be done wholly or in part on the man's own time. Either way can be satisfactorily worked out. The course should embody at least an elementary and thorough training in the wage-payment system in use; the operation of the budget system, if any; cost control; handling of men; elimination of waste and scrap; cleanliness and kindred topics. I believe that this education should extend to the point where the man is taught as much as possible of the company's business. The more he knows of the company's general methods and position, of the functioning of departments other than his own and of the interrelationship of departments, the keener and more intelligent will be his interest in his own job and department.

From experience I believe that a foreman can be educated to the point where his conception of his job is that he is general manager of his department, buying materials from stock or other departments and selling his finished product to the plant. Essentially, a good foreman is just that. This is not a visionary solution but a happy actuality in some plants, and is a condition that can be reproduced in any company with the intelligent installation of the correct training course. Such a course can be introduced and maintained at a surprisingly low cost and will produce golden dividends on a copper investment.

Compensating the Sub-Executive

Compensation for sub-executives has been given less consideration than either their selection or training. In general, the present method is to pay the individual as little as possible during good times and to lay him off when business is bad. This method probably is satisfactory to everyone except the sub-executive who gets the axe. For selfish reasons, at least, it should *not* be satisfactory to the company. Considerable money has been invested in this indivduial, he has been trained to a certain function in the organization, and his worth should be realized and recognized by a retention of his services through the depression period.

An intelligent plan for accomplishing this can be worked out and applied. In general, the sub-foremen and foremen can be paid with the group over which they have supervision. If conditions demand such a move, these men may be reduced temporarily to the status of working operators in that group. The procedure with respect to other sub-executives, such as time-study men, however, is not so simple, but this could be accomplished.

I am presupposing that we are discussing a modern plant and that this plant is operating a budget system, under which all its costs and sales are intelligently prognosticated. Why could we not put the salaries of these sub-executives on the basis of a nominal drawing account? The amount could be determined by a survey of current living conditions and set at a figure that would provide the individual with enough to live upon decently. The balance of his compensation would vary with the sales scheme of the company and with the efficiency of his own performance. Obviously, in periods of good business, he would receive a total compensation much higher than the nominal drawing account. In periods of depression he would receive only his drawing account. Careful installation of such a scheme would permit a reasonable balance over a period of time which would practically even up the peaks and valleys. Such a plan is possible and can be worked out in detail for any individual application.

In conclusion, if we are to hope for any substantial advance in our unit of the industrial army, we must give more heed to our non-commissioned officers. They are the backbone of our regiment and in their hands and hearts lies our hope of victory.

THE DISCUSSION

A MEMBER:—I am glad Mr. Lefebvre touched upon one or two points that seem to have been utterly and absolutely neglected throughout our past industrial crisis. When schedules are arranged or altered in a plant or when models are changed, the planning department can predict how much money will be lost and how much value will be scrapped, if and when that change is made. For instance, if a type of car is to be discontinued and a new program started, the planning department can tell exactly how much overrun we have on this, that or the other piece, how much stopping production of that car on a certain day will cost and how much at a later date. The whole process is very definite, so that a definite figure as to what any change in policy will cost can be presented to the management of the plant from a material standpoint. Absolutely no mechanism is available to present to the management the cost of changes in the organization.

At the beginning of the year I hoped that some method of evaluating the cost of these men could be found. In fact, I had a rather ambitious program, but I ran up against one stone wall or another and progress was impossible. On the other hand, if the Production Activity can find a way for the production man to present his problems to the management in terms of dollars and cents, the value of that production man will be recognized. Now he is set down at par by the management and accountants. If he beats that figure he is all right, until it is reset to par again.

The S.A.E. can be of great value to industry in the

production side if the thoughts that Mr. Lefebvre has started can be continued, not in the short year in which we hope to do it, but probably extending over three, four or five years. Even if getting across the point that the intangible values in the production man's function should be put in more concrete form takes 10 years, the effort is well worth while.

Sub-Executive's Value to His Organization

JOSEPH GESCHELIN[2]:—In the last two years I have talked with a number of men who have all been troubled about their minor executives, particularly because they are afraid of the effect of present conditions upon the morale of these men. The men who are rather close to their operating budgets and wage plans of various kinds are the only ones who seem to realize that the value and effectiveness of these plans depend entirely upon the spirit with which the instructions are carried out by the men. I know that in many cases the sub-executives are going farther than their instructions, and sometimes they make savings that are outside the line of duty.

Mr. Lefebvre spoke about the results of his practical experience. I had occasion to study his work at the Oakland automobile plant, at least a number of phases of factory management, and can say that he was able to put into practice at the time he was there everything he mentioned in his paper.

In evaluating the sub-executive in dollars and cents, the important element is to convince the management that it has an investment there. To find any measuring stick has been very difficult. Some of the men who teach at various universities and who are doing considerable work in industrial research have told me that the academic man has just about thrown up his hands and does not seem to know how we can measure that investment. At the last annual meeting of the American Society of Mechanical Engineers, a member from Cincinnati said that the value of his foremen was not $5,000, as Mr. Lefebvre mentioned, but actually $10,000. In that case, the value perhaps was exaggerated, but the speaker claimed that this figure was a very fair estimate of what these men were worth to his company.

Explain How a Job Should Be Done

W. W. NICHOLS[3]:—Mr. Lefebvre brought up one very important point about the management interviewing the men before they are made sub-executives. We all have seen cases of some manager or sub-executive having a favorite in his gang. When an opening came, that man was promoted regardless of his capability for directing the gang. I have found that it always paid to tell a man why I wanted a job done in a certain way, instead of merely telling him to do the job and, after he has done it to the best of his ability, berating him for not doing it in the way that conformed to my ideas. No matter how good a foreman or sub-foreman we may have, a time always comes in his work when he does not want to assume the responsibility. In nine out of ten cases his idea of how a job should be done is right, but he does not want to take the responsibility.

Those who are not from Detroit may be interested to hear that night courses for training minor shop executives are given at the University of Detroit four nights a week. The men are given drawing, English and mathematics in a three-year course, which is entirely free except for the textbooks. Next September, a class for teaching the fundamentals of time study will be started. The necessity for that class is great. We have too many clockers and not enough real time-study men. In going through plants, I see many of them who know very little about the correct positioning of work, the correct form of tools, the correct feeds and speeds at which to run machines, and very few men around the plant who seem to take enough interest to educate them on that subject.

Mr. Lefebvre's plan for compensating minor executives is a good one, and I should like to see it installed, but, like everything else in that line, it will be too radical for many companies to install for some time.

Engineering Department and Shops Should Cooperate

Closer cooperation between the engineering department and the shops is one phase that was not mentioned in the paper. Last summer I was asked to give a paper before the foremen of the Skoda Works in Pilsen, and I chose as my topic, The Foreman's Position in Industry. In that paper I said:

> I have not been in your country long enough to determine what the conditions are here, but I do know that in the majority of the European shops the cooperation between the engineering departments and the shops is not close enough. The majority of your engineers are college graduates, and many of them consider it beneath their dignity to even speak to workmen. This necessitates the transmission of their ideas and instructions through three or four different persons before they reach the right men, with the liability of misinterpretation. Until that condition is corrected, you will never be fully successful.

That paper was given with some of the engineers and managers of the Skoda Works sitting right there in the front row, and I have since heard that it has done considerable good. That thought never had been brought to them by a foreigner before, but what struck them most forcibly was that, after the paper had been read, I told the man who read it for me in Czech to tell those men that I would be very glad to shake hands with each of them as they left the room. In Geneva I received a letter from him saying that several of those foremen had told him that it was the first time they had ever shaken hands with a man in my position. My right arm was about paralyzed in returning the salutes in going through that plant.

A MEMBER:—I was railroaded into a production organization that was founded on the premise that, if the instructions were written thoroughly enough, absolutely no intelligence would be required to carry on the functions of the company. The prints, charts, and routings were to be most complete, and all that was required of the workmen was to be able to read and write and have enough fingers on each hand and enough energy to make the necessary movements.

One time a special lot of cylinder blocks having too much deviation for using the regular tool were going through the plant. Work was done at night, and in the morning the inspectors were astounded to find that some of the holes for the cylinder-head studs in the top of the block had been drilled only ½ in. deep, while some of them went clear through the boss and into the water-jacket. They varied from ½ in. to all the way through, which was about 1⅛ or 1¼ in.

When the situation was explained rather forcefully to the foreman and finally to the man, the latter insisted that he had followed his instructions literally, and so he had. They showed him the blueprint with the specified depth of the hole, but he produced another document that directed, "Operation No. 4: Drill 7/16-in. hole; standard time, ¾ min." So he had carefully drilled each one of those holes ¾ min. deep, by the watch. That probably is the only case I know of in which the watch was used for a depth measure.

[2] M.S.A.E.—Engineering editor, *Automotive Industries*, Philadelphia.

[3] M.S.A.E.—Vice-president and mechanical engineer, D. P. Brown & Co., Detroit.

T. J. LITLE, JR.[4]:—I have always been extremely interested in production, because, if we want to know something about our own plants, we should spend considerable time in them. Furthermore, I have discovered that many times the sub-executive may know much more about his job than does his superior; so, no matter how high my own job might be, mingling with the foremen in our plant was helpful. If we really want to know how the production is passing through the plant, we must talk to these men; and to do that is beneath no man's dignity in my estimation, because he learns considerable in that way. In fact, in going through the plant, a good idea is to ask the sub-foreman if he is satisfied with the design, even though you have made it; you will be surprised to find that you get very valuable tips from those men. They will tell you how to short-cut certain machine operations and how to simplify designs for the good of the company. That is one phase of the situation which very often is not understood. The engineering executive should unbend and mingle more freely with the men down the line.

Should Train Apprentices at Shop Schools

MR. NICHOLS:—In going through the Borsig plant in Berlin and the one in Essen, each of which maintains a school for apprentices, the thought came to me that there was the place to instruct the time-study man and the boys in the correct feeds and speeds at which to operate the machines. So I asked, in both of those plants, "What is being done to instruct the time-study men in these schools and what is told the boys about the correct feeds and speeds?"

To both questions the reply was made that nothing was being done, since the old machine hands, who were more interested in keeping up the piecework prices than they were in getting production, would teach the boys the correct feeds and speeds when they entered the shop. I insisted that these schools should teach the boys the correct methods to be pursued in making time studies.

In a very interesting talk with the superintendent of the school in Essen, he said that part of this work was being done by engineers in the technical schools of Essen. I replied that there lay the cause of the trouble, because the boys have not had the shop atmosphere.

We must correct those two points in our institutions here in the United States. Our time-study men in many plants give a clerk a stop-watch and a board and send him out to take the times on the jobs, and the operator puts it over on him every time. The observer does not know whether the operator is running his machine correctly or not or if the tools are properly or wrongly ground. The tool-grinding question in many shops today is simply a grind. In one plant in which I was working, I absolutely refused to do anything more until they learned how to grind the tools.

[4] M.S.A.E.—Consulting engineer and industrialist, Detroit.

Noise and Heat Control in the Automobile Body

(*Concluded from page* 210)

As the driving force moves the panel in one direction, the air is slightly compressed on the side toward which the panel moves and the sound is propagated in that direction. If an absorbing material of a porous nature is placed on this side, the compressed air, instead of being propagated as a sound wave, tends to enter the absorbing material. As the absorbent panel moves back and forth, the air rushes in and out of the material and the coupling to the atmosphere, and consequently the sound wave is lessened.

Panels Couple with Low-Frequency Sounds

We have noticed that body noises are particularly annoying with certain types of sound when the window is open. I have in mind particularly the exhaust. When this gives rise to low-frequency noises, the result is bad as far as the body is concerned, because low-frequency noises couple with the body panels more than do high-frequency vibrations. Low-frequency sounds in particular sometimes seem to get underneath the car and vibrate the floor-boards. When this occurs the condition of the air in the car is similar to that inside a drum, although the magnitude of the effect is less.

When one noise is eliminated, another noise often is heard, which is unfortunate as regards body engineering. Airplane noise is about 50 per cent propeller and 50 per cent exhaust noise. Neglecting the commercial aspect for the moment, virtually all of the exhaust noise can be prevented, the 50 per cent caused by the propeller being left. As far as loudness is concerned, which is psychological and physiological, removing 50 per cent of the physical intensity of the total sound corresponds roughly to a drop of 3 steps in loudness out of a possible 130 steps. I think this shows that as many sources of noise as possible should be attacked.

High-Frequency Vibrations Required Deadening

C. L. HUMPHREY:—We have had a different theory regarding panel vibration. I should say that low-frequency vibration is very desirable. We used to get high-frequency vibrations in panels in the early days when drawing of the stampings had not been perfected. To eliminate high-frequency vibration, putting something on the panel was necessary to break up the vibration period. In adding a deadening material, all we do is to lower the frequency, and lowering it out of the range of chassis vibration is not necessary. On the other hand, with the low-frequency period, we do not have to add much felt or Celotex to reduce the panel frequency below the audible range.

Regarding penetration through felt, we found that adding the cardboard facing was very desirable, not only for appearance, but because, as the sound waves pass through the felt, they hit the cardboard and its reverberation throws them back, deadening the sound waves in the felt.

MR. JACK.—I think that changing the pitch does have a good effect. However, the problem of changing the pitch to get a blending effect is far from simple, and I think that it offers a large field for work.

CHAIRMAN C. B. PARSONS[5]:—We all realize that this is a very important problem and one that will be given more study in the future than it has had in the past, although considerable excellent work has already been done, particularly in connection with the mounting of the body on the chassis in such a way as to prevent noises from the chassis being transmitted to the body.

[5] M.S.A.E.—President, Parsons Co., Detroit.

Development of a Heavy-Duty V-12 Engine

Annual Meeting Paper

By Hubert Walker[1]

REASONS for designing an engine with 12 cylinders for fire apparatus, motor-trucks and motorcoaches are set forth by the author. Among them were the requirement for 225 hp., a speed range of 200 to 3000 r.p.m. with little torsional vibration and torque-reaction effect, and economy of space. The design adopted has its cylinders in two rows of six each, disposed at an included angle of 30 deg. The statement is made that it can be installed in the space occupied by a 150-hp. six-cylinder engine.

Advantages claimed for setting the cylinders at this angle are that the engine can be made narrow, so that all cylinders and the crankcase can be cast in one block; that the accessories can conveniently be placed outside; and that the synchronism of impulses that causes torsional vibration can be avoided.

Vertical valves are operated from a central overhead camshaft by rocker arms that carry rollers at one end and are split horizontally at the other end. A set-screw is provided to adjust the split portion for valve-stem clearance without itself coming into contact with the stem. The camshaft is driven by a double-faced silent chain running over one idler and the water-pump sprocket, the adjustment being designed so that it will not change the timing of the camshaft. Fuel-pumps are operated by cams at the front end of the camshaft.

Factors of safety in the engine are said to be higher than in other heavy-duty automotive engines. The first engine of this design was tested for 4000 hr. with only two valve grindings; negligible wear on the working parts, including the chain; and the replacement of only one small part, the design of which has since been revised.

FOR many years prior to 1931, fire apparatus which satisfactorily met all requirements for reliability, pumping and road performance was produced by the company with which I am connected. With the increase in distance that fire apparatus is required to cover and the improvements in streets and highways, establishing new standards of performance has become advisable. Acceleration ability comparable with that of passenger-cars having top speeds of 70 to 80 m.p.h. must be possible. These requirements could not be satisfied by engines of existing designs having the required horsepower, principally because of insufficient speed range.

All types of highway transportation are facing a similar problem in meeting the public demands for smoother and quieter engines and reduced running schedules. We need smooth, vibrationless engines, to reduce rider fatigue, having greater operating range, horsepower and top speed, to give faster acceleration and to reduce the time en route.

With the continuous improvement in our highway system, motor-truck and motorcoach operators can reduce their running time if the required type of powerplant is made available. The rate of traffic flow is determined in our heavily populated areas by the slow-moving vehicles, which congest and restrict traffic and cause needless time loss to operators of such vehicles and to drivers of private cars. An engine designed to meet the needs of our company would also satisfy a growing demand in the truck and coach field for an improved powerplant.

We first established certain specifications for an engine to meet these requirements, as follows:

(1) Minimum brake horsepower, 225
(2) Speed range, 200 to 3000 r.p.m., to meet widely varying road conditions
(3) A type capable of producing the maximum horsepower output per pound of weight and per cubic inch of piston displacement
(4) Absence of crankshaft torsional vibration within the operating range
(5) Reduced torque-reaction effects
(6) Simplicity of arrangement of units and accessibility for service
(7) Minimum space occupied by power unit
(8) Heavy-duty design, in the sense of exceptionally high strength-stress ratios throughout

Reasons for Selection of the Type

The first step in the solution of the problem was the selection of the type of engine to most satisfactorily meet these requirements.

Engines of the L-head and valve-in-head types have been produced in quantities and over a sufficient period to establish averages of 0.27 b.hp. per cu. in. of piston displacement for the L-head type and 0.30 hp. per cu. in. at or below 3000 r.p.m. for the valve-in-head type. To satisfy (2), we selected the latter type to favor the weight factor and to secure higher thermal efficiency. With its power-displacement ratio, an engine of 750-cu. in. displacement was required to meet the minimum power needs.

The inherent balance of the six-cylinder engine recommends its consideration, but speed-range limitations due to the cylinders having a unit displacement of 125 cu. in. compelled the selection of an engine having a greater number of cylinders with smaller unit displacement. The best commercial six of comparable power that is in production has very much less acceptable ratios of power to weight and size; also, the maximum safe speed is only 1600 r.p.m. Our conception that normal speed ranges up to 3000 r.p.m. are of value in road performance and that these high speeds make for better ratios of power to weight and size limited the piston displacement to 70 cu. in. per cylinder, and the necessity for a total displacement of 750 cu. in. determined the number of cylinders.

Obviously, an eight-cylinder engine of the required total piston displacement would have a unit piston displacement too great to permit of the required speed range with satisfactory commercial durability. To give the established displacement figure, a 4-in. bore and a 5-in. stroke were selected, in preference to 4¼-in. bore and 4½-in. stroke, for two principal reasons: (*a*), re-

[1] M.S.A.E.—Chief engineer, American-LaFrance & Foamite Corp., Elmira, N. Y.

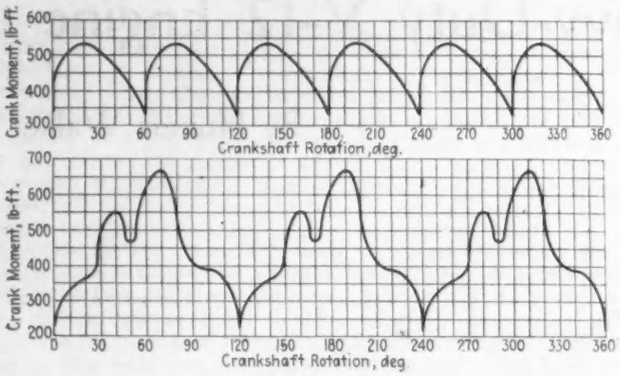

FIG. 1—CRANKSHAFT TURNING MOMENTS OF V-12 ENGINES

(Upper) Synchronous Curve Produced by 60-Deg. Angle Giving Equal Spacing and Firing Intervals. (Lower) Irregular Non-Synchronous Curve Produced by 30-Deg. Angle Giving Unequal Spacing. The Average Moment in Each Case Is 449 Lb-Ft.

duced engine length, because of smaller bore, and (*b*) increased thermal efficiency, owing to longer stroke.

We elected to build a dual six, which has all the simplicity of the six that is important for the operator and the mechanic; and we have, in effect, two six-cylinder engines operating on a single six-cylinder crankshaft. Timing and carburetion of each bank of cylinders are handled exactly as in a conventional six.

The V-12 is shorter than the six or the in-line eight of the same displacement, so will fit with minimum changes into chassis already in production. Shortness of the crankshaft means greater rigidity, thus reducing vibration; and the greater number of cylinders permits the use of a small flywheel, decreasing the weight and the fuel consumption. The flywheel need be of only sufficient size to carry the starting-motor gear.

The small bore and stroke means smaller inertia loads and an increase in the range of safe operating speed to and beyond the figures specified. Thus the V-12 incorporates all the known features required to produce the ideal engine for modern highway transportation up to a capacity of 250 b.hp.

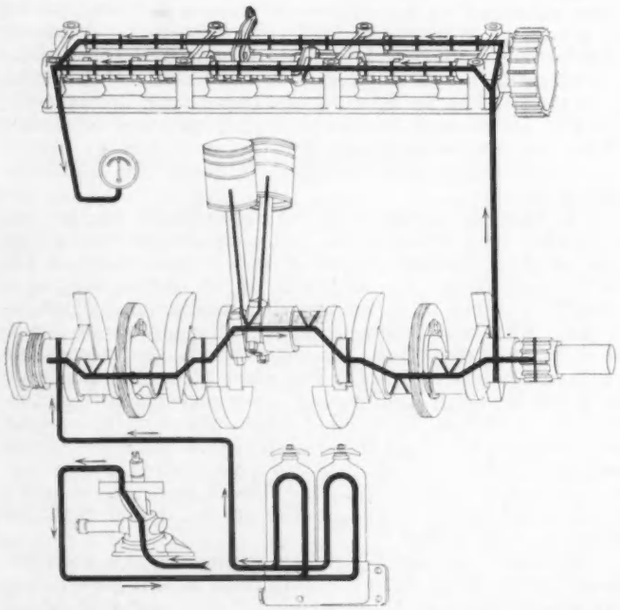

FIG. 2—DIAGRAM OF OILING SYSTEM OF AMERICAN-LAFRANCE 240-HP. V-12 ENGINE

Double Filtration Is Provided and the Pressure Gage Is Located at the Extreme End of the System

Arrangement of Cylinders and Accessories

The next phase of our problem was the arrangement of cylinders and accessories. An included angle of 60 deg. between the cylinders will produce even spacing for firing but results in an engine so wide that accessories and the induction and exhaust systems must be placed between the banks, forcing compromises that mean sacrifices in efficiency, power and accessibility. Reduction of the angle to 30 deg. solved the problem of width and made possible the following advantages:

(1) All accessories are outside, where they are accessible.
(2) Cylinder block and crankcase are cast as a unit, assuring rigidity of crankcase and alignment of bearings and cylinders.
(3) Overhead mounting of the camshaft eliminates push rods and tappets and, with the narrow V angle, permits vertical valves.
(4) The 30-deg. angle changes the turning moments to varying values, producing a non-synchronous torque curve of irregular shape. This characteristic is valuable in eliminating vibration.

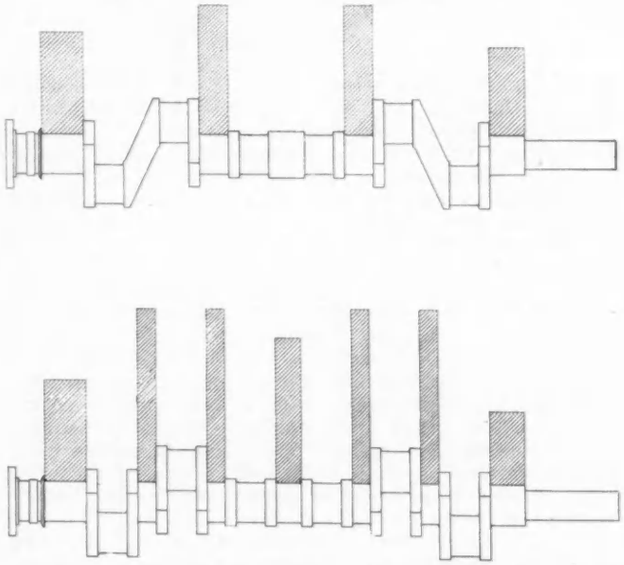

FIG. 3—COMPARATIVE BEARING LOADS ON FOUR-BEARING AND SEVEN-BEARING CRANKSHAFTS

The Shaded Areas Are Proportional to the Unit Pressure on the Bearings

The crankshaft turning moment for a 60-deg. 12-cylinder engine with equal firing intervals produces a synchronous curve, such as the upper curve in Fig. 1. The irregular non-synchronous curve for the 30-deg. engine is shown below for comparison.

Provisions for Long Life and Accessibility

For heavy-duty design, lubrication of all moving parts is of paramount importance if long life is to be realized. Fig. 2 is a schematic diagram of the lubrication system, having 100-per-cent filtration through all-metal filters. The crankshaft is drilled through to eliminate all piping to bearings and preclude all possibility of loose or broken connections. This design also assures cooler bearings, resulting in longer life. The timing chain at the forward end is also positively lubricated

by a valve, in the front end of the crankshaft, which opens to reduce the pressure, allowing oil to flow out through the crankshaft sprocket to lubricate the chain. Oil under pressure also flows up to lubricate the camshaft bearings, rocker arms and rollers. The pressure gage is connected at the rear of the cylinder block so that it registers pressure at the extreme end of the line, providing assurance that the oiling system is functioning properly.

Length of an engine is determined by size of the cylinder bore, water spaces around the cylinders and length of main bearings. An analysis of bearing loads indicates that the shortest engine is obtained with the four-bearing shaft. Fig. 3 indicates for comparison the unit loads per bearing for four- and seven-bearing crankshafts for engines of the same size and same length of shaft. A definite trend to fewer and larger bearings, with resultant longer life and freedom from misalignment, is evident. Our reason for selecting the four-bearing design is therefore obvious.

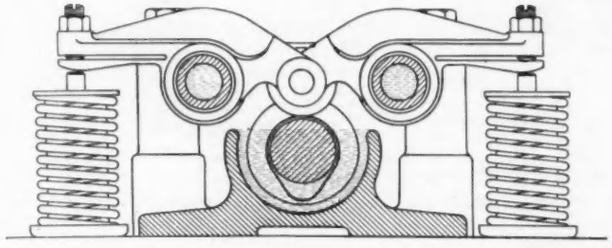

FIG. 4—METHOD OF LUBRICATING VALVE-OPERATING CAMS AND ROLLERS

The Camshaft Support Is Formed into a Trough That Receives the Overflow of Oil from the Camshaft Main Bearings

Full counterweighting of the crankshaft was decided upon, to reduce bearing loads, thus contributing to the life of the engine.

Side-by-side connecting-rods were adopted, for interchangeability and simplicity. The rods are drop-forgings, machined all over, heat-treated, and drilled for pressure lubrication to the piston-pin. Centrifugally cast babbit is used in the crank end for good heat transfer and lightness. A pilot is provided on the big end for machining the babbit, assuring uniform thickness at all points.

Aluminum-alloy pistons of the solid-skirt type, with a new method of ringing, were selected after numerous tests had indicated this type as the most desirable for heavy-duty service.

The cylinder-head design was given special attention for adequate cooling of the valves. Direct wash of all valve seats is incorporated, eliminating valve warpage and seat erosion. The camshaft is mounted on the engine center-line, above the heads, reducing the number of parts and the inertia value of the valve mechanism. Rigidity and simplicity are obtained by this arrangement.

Lubrication of the cam and roller faces is provided by making a trough of the camshaft support as shown in Fig. 4, which also shows the rocker-arm design and the method of adjusting the valve-stem clearance which provides simplicity and stability of adjustment. A separate cam and rocker-arm are provided for each valve. Overflow from the camshaft main bearings supplies the requisite oil.

Dual valve-springs were adopted after extensive tests had indicated their superiority for high speed and freedom from surge. Fig. 5 shows the spring-force curve and the acceleration-force curve at 3000 r.p.m. of the engine. As these curves do not intersect, no drift of the valves occurs within the operating range. Surge is eliminated by selection of coil diameters and wire gages such that the inner and outer springs will not respond to simultaneous periods. The accessibility and simplicity of the valve arrangement are shown in Fig. 6.

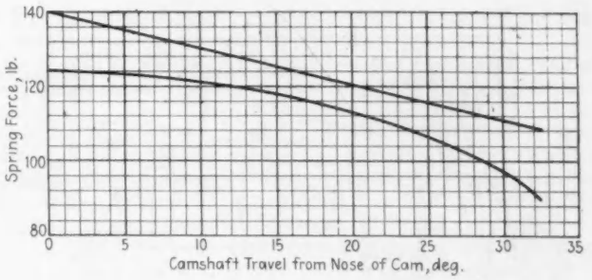

FIG. 5—FORCE CURVES OF DUAL VALVE-SPRINGS

Upper Curve Shows Total Force Exerted by the Springs. Lower Curve Shows Total Inertia Force of the Valve Train at 3000 R.P.M.

Novel Accessory Drives

The problem of distributor drive was solved by the novel arrangement shown in Fig. 7, the driving gear on the crankshaft meshing with the pinion on the end of the distributor shaft. Two driving gears are carried on the crankshaft, each driving two distributors and the rear gear also driving the oil-pump. At a crankshaft speed of 3000 r.p.m., the slipping speed of these gears is in excess of 6000 ft. per min. This departure from all known precedents in gearing has resulted in no sacrifice in durability.

Each distributor unit is carried by a separate housing supported in the crankcase and located in position with

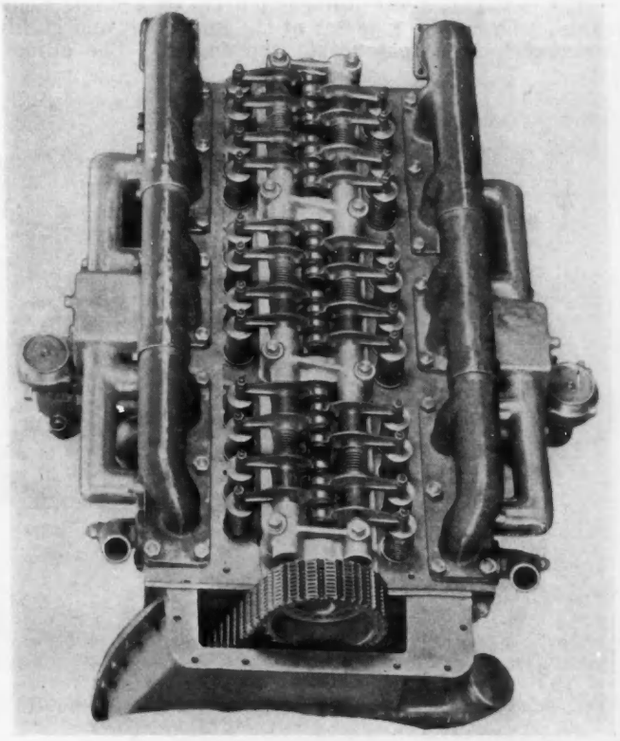

FIG. 6—OVERHEAD-VALVE ARRANGEMENT, SHOWING SIMPLICITY AND ACCESSIBILITY

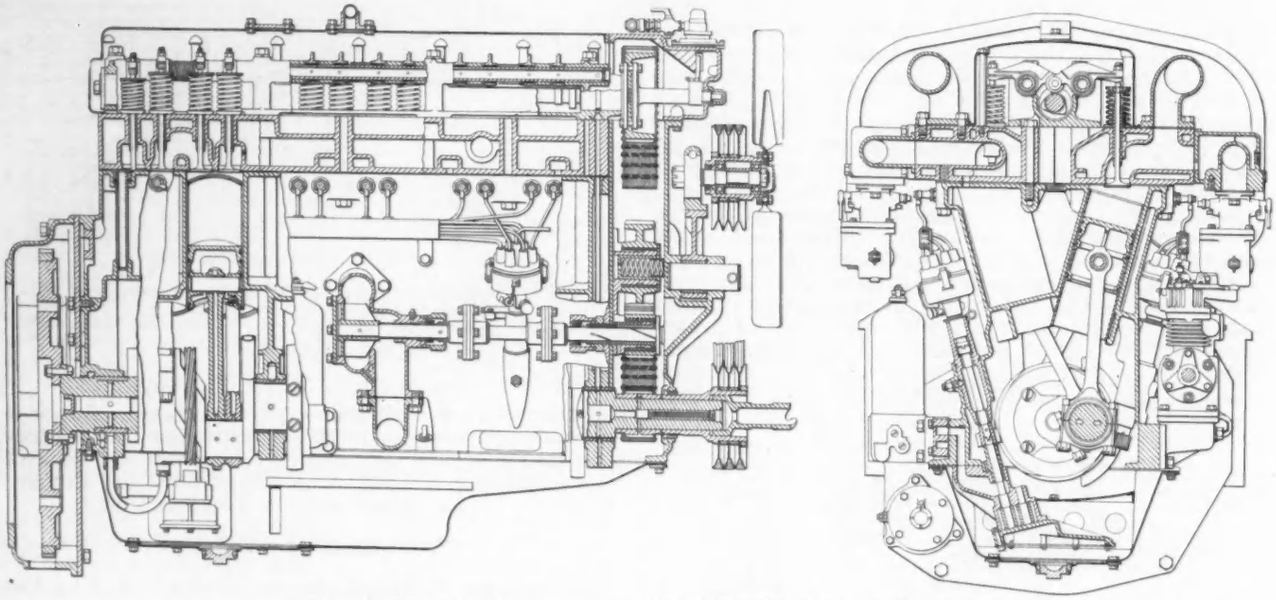

FIG. 7—PARTIAL LONGITUDINAL AND CROSS-SECTIONS OF ENGINE

Note Worm-and-Gear Drives from Crankshaft to Distributor Shafts, Shown in Section at the Right. The Worm toward the Rear End of the Crankshaft Drives a Second Pair of Distributors and also the Oil Pump. An Extension of the Camshaft at the Top Drives the Fuel-Pumps

a set-screw and lock-nut. Thus each unit can be removed at will, or any other part of the engine removed, without disturbing the timing. Independent double ignition is required for fire service by the National Board of Fire Underwriters, and it proves a desirable safety factor against ignition failures on the road for motor-truck and motorcoach operators.

The camshaft and water-pump drive by a single silent chain, seen in Fig. 8, is one of the important and highly successful novel features of the engine. The adjustment is manual, and any adjustment that may be required for chain wear or stretch will not affect the timing of the engine. Freedom of this design of chain drive from the undersirable loads of the fan and air-compressor assures unprecedented chain life. The fan, generator and air-compressor are driven by multiple V-belts, as seen in Fig. 9, providing simplicity and accessibility.

With economy and ease of servicing in mind, dry sleeves are provided in the cylinders, eliminating all

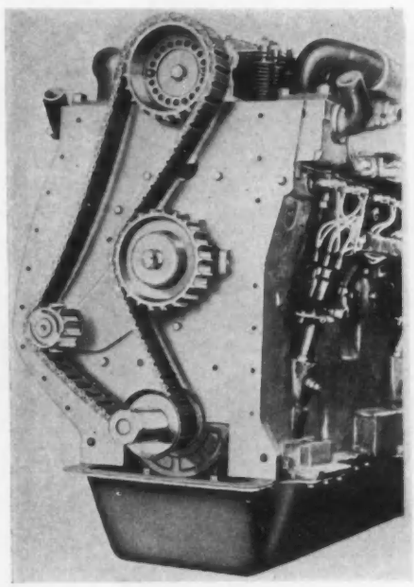

FIG. 8—NOVEL SILENT-CHAIN DRIVE FOR CAMSHAFT AND WATER-PUMP

Manual Adjustment Provided for Taking Up Stretch or Wear of the Chain Does Not Affect the Timing

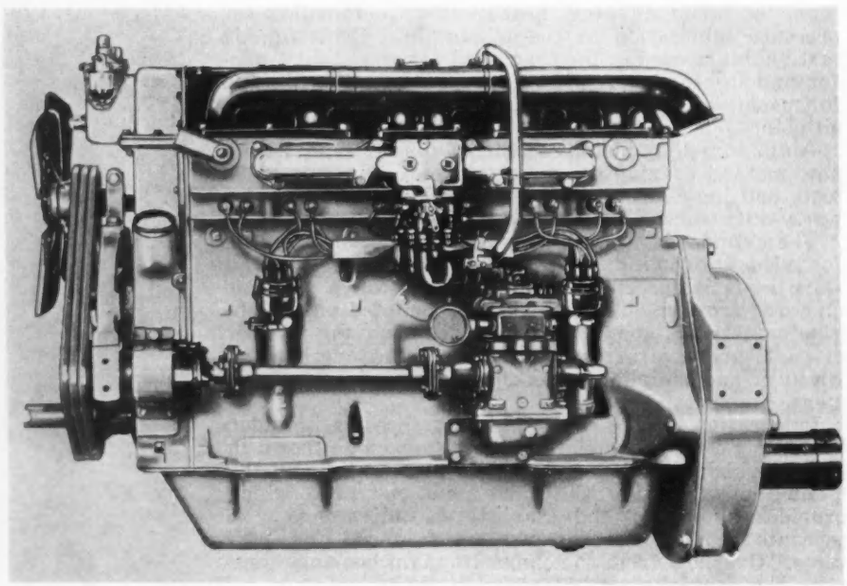

FIG. 9—LEFT-HAND SIDE OF ENGINE, SHOWING MULTIPLE-BELT DRIVE TO FAN, GENERATOR AND AIR-COMPRESSOR

wearing surfaces from the cylinder block. The bores can be quickly restored to original diameters without grinding or removing the block from the chassis.

Fuel-pumps are provided at the front end and are driven by an extension of the camshaft. This drive is illustrated in the combined side view and longitudinal cross-section of the engine in Fig. 7. Each carbureter is supplied by a fuel-pump of capacity such that, in event of the failure of one pump, the remaining pump will supply fuel to both carbureters in sufficient quantity to provide for full power from the engine.

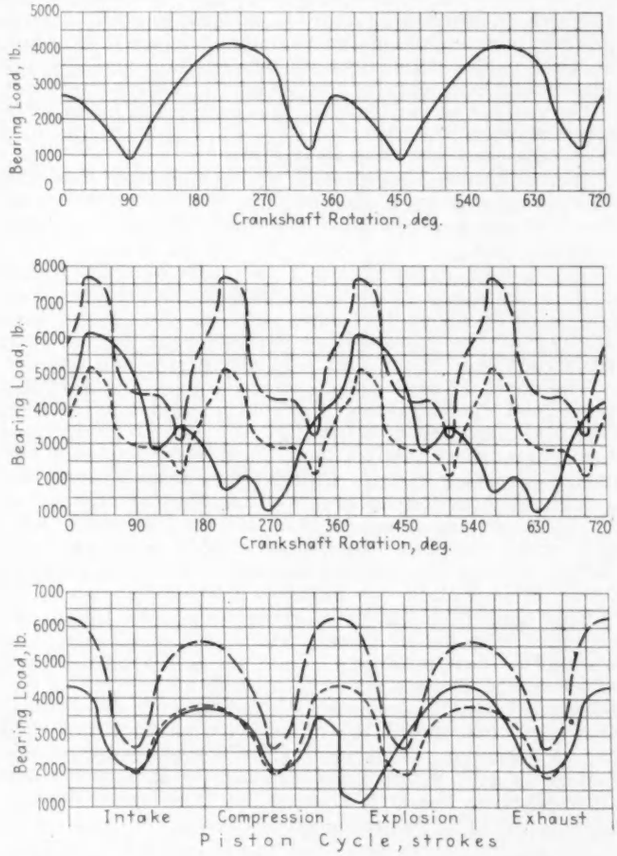

FIG. 10—CURVES OF CRANKSHAFT MAIN AND PISTON-PIN BEARING LOADS

(Upper Chart) Rear Main Bearing: Total Mean Load, 2542 Lb.; Load per Square Inch of Projected Area, 291 Lb.; *pv*, 12,445 at 2800 R.P.M.

(Middle Chart) Crankshaft Intermediate Bearing

	Solid-Line Curve	Lower Dash Curve	Upper Dash Curve
Full Load at	2,800 R.P.M.		
Kinetic Load at		2,800 R.P.M.	3,400 R.P.M.
Total Mean Load, lb.	3,201	3,366	4,948
Load per Sq. In. of Projected Area, lb.	406	427	628
pv Factor	17,381	18,280	32,620

(Lower Chart) Crankpin Bearing

Full Load at	2,800 R.P.M.		
Kinetic Load at		2,800 R.P.M.	3,400 R.P.M.
Total Mean Load, lb.	2,982	3,160	4,657
Load per Sq. In. of Projected Area, lb.	867	919	1,354
pv Factor	29,146	30,890	55,270

The inlet manifold is of the straight-bar four-port type, with automatic hot-spot. The two center exhaust ports are of the T-type, exhausting into the inlet-manifold heat chamber as well as into the exhaust manifold. The quantity of heat supplied to the inlet-manifold riser is controlled by the size of the heat-inlet port.

This V-12, as designed, can be used in existing chassis to replace virtually any six-cylinder engine of 150 b.hp. or more. This feature was requirement (7) in our original specification and is most important for truck and coach operators requiring improved power units.

Adequate cooling is a very important consideration. Notwithstanding its greater power output, the engine actually runs cooler than most 175-b.hp. engines when using the same radiator. In our own fire equipment, we have been able to use the same radiator, changing the fan from six to four blades of the same diameter, and running with an average engine-outlet temperature of 160 deg. fahr. in atmospheric temperatures of 90 to 95 deg.

Vibration Elimination and Bearing Loads

The greater number of cylinders obviously produces a decreased torque vibration. The shorter crankshaft, with its inherent stiffness, and the 30-deg. cylinder angle have combined to produce absolute freedom from

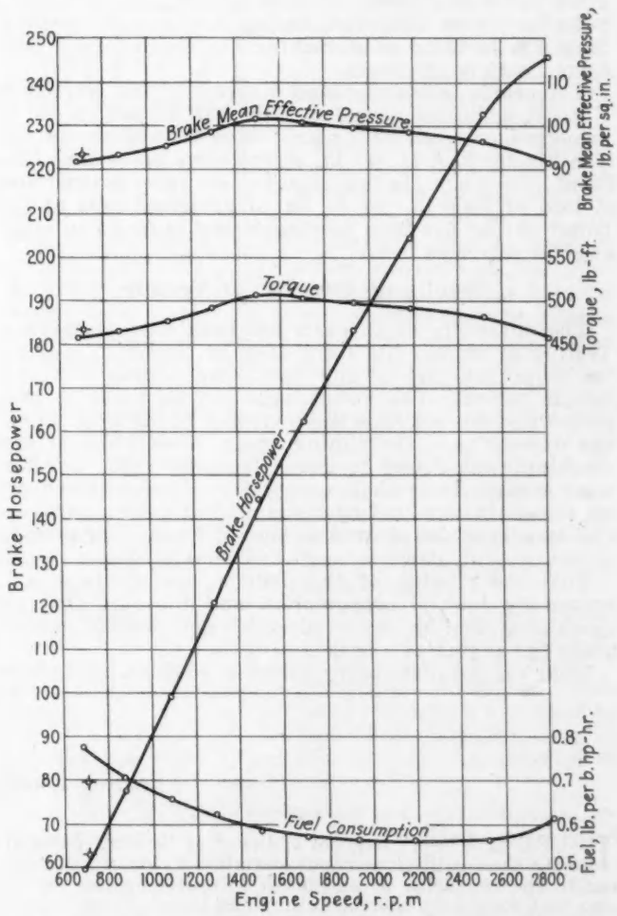

FIG. 11—POWER, TORQUE, MEAN-EFFECTIVE-PRESSURE AND FUEL-CONSUMPTION CURVES OF V-12 ENGINE

Duration of the Test Was 2.5 Hr., and the Engine Had Been Run for 47.25 Hr. Preceding the Test without Carbon Removal or Valve Grinding. All Runs Represented in the Curves Were Made with Carbureters Adjusted for Maximum Power at 1500 R.P.M. Additional Points Indicate Runs for Which the Carbureters Were Readjusted for Maximum Power at 700 R.P.M. The Fuel Used Was Texaco Regular Gasoline. The Fuel-Consumption Curve Is Actual, and the Horsepower, Torque and Mean-Effective-Pressure Curves Are Corrected to 29.92 In. of Mercury and 60 Deg. Fahr.

torsional periods throughout the entire operating range and a smoothness that has never before been obtained in a heavy-duty engine. Minimum mass vibration has been obtained by correct balance of all rotating parts and by reduced inertia forces.

In the load diagram for the rear bearing reproduced at the top in Fig. 10, an average load of only 291 lb. per sq. in. of projected area is indicated at 2800 r.p.m., the speed of peak power, and in the chart of the intermediate-bearing load, as indicated by the heavy solid line, in the middle chart in Fig. 10, an average load of only 406 lb. per sq. in. is imposed at 2800 r.p.m. with full power output. These figures reveal the factors of safety incorporated in the engine, which are higher than ever before incorporated in a heavy-duty engine for automotive service. The lower broken line indicates the kinetic load at 2800 r.p.m., such as would occur when coasting down a hill and using the engine as a brake. The upper broken line indicates the kinetic load at 3400 r.p.m., which is considerably over the rated speed; but the average load is still only 628 lb. per sq. in. of projected area.

Although the assertion is often made that more engines fail going down hill than up hill, grades 7 and 8 miles long were descended during our tests at speeds of 55 m.p.h. in third gear, making the engine speed 3900 r.p.m., with no ill effects.

The crankpin bearing-load diagram at the bottom, in Fig. 10, indicates a load of only 867 lb. per sq. in. of projected area at 2800 r.p.m. with full power output. The kinetic load is 919 lb. at the same speed and 1354 lb. at 3400 r.p.m., as indicated by the upper broken line. A load of 1500 lb. per sq. in. of projected area at full power output has been acceptable and is found in many engines produced today.

Results of 4000 Hr. of Testing

The durability of all parts has been most gratifying. Testing of engine No. 1 for 4000 hr. failed to indicate the expectable life of any part. We believe this is a unique record. The valves were ground twice in that period and did not show any evidence of sticking, warpage or erosion. The timing chain, after removal and checking, was found to have stretched 1/32 in. The wear was so little that, except for discoloration from oil, the chain could not be distinguished from a new one. The sprockets also showed no sign of wear. The pistons were worn only 0.001 in. and were 0.001 in. out of round.

That the ringing of the pistons was excellent was proved by low oil consumption and the fact that no spark-plug fouling occurred on 7 and 8-mile grades, using the engine as a brake.

Wear on the distributor gears in 4000 hr. of service was so small that it could not be measured with ordinary instruments, although the engine contained no oil-cleaners or provision for oil filtration.

With our own tests completed and still desiring further data, engine No. 1 was installed on a Greyhound coach in which it operated for 40,000 miles with a record of failure of only one part. In the original construction, a stamped-steel valve retainer was used, which failed in the high-speed coach service. This was then changed to a machined-steel retainer, which laboratory tests show will pull the valve stem apart before the retainer shows any sign of failure. We have never had one of the dual valve-springs break. The reasons for this record are high factors of safety, greater internal rigidity, low unit loads on bearings, correct lubrication, vertical valves with adequate seat cooling, and low unit piston displacement in proportion to total horsepower.

Curves for power, torque, fuel and brake mean effective pressure are given in Fig. 11. The specific data were taken largely from engine No. 1.

Our minimum specification for horsepower was 225, but 240 hp. has been exceeded and more than 20 of the first 100 engines produced exceeded 250 b.hp. on dynamometer test.

The torque curve shows a variation of only 10 per cent in the speed range from 1000 to 2800 r.p.m., with the peak of about the same value as for six-cylinder engines of the same piston displacement but without their narrower range and very sharp rise and descent.

The curve of brake mean effective pressure indicates very good fuel mixture, distribution and manifolding. The fuel curve, from actual figures, with no corrections for temperature, shows very good economy over the entire operating range. Comparative tests have shown a fuel consumption no greater than that of engines of 175 b.hp. moving comparable loads over the same routes and under the same conditions. This economy, with faster acceleration, higher top speed and less time en route, is important for highway transportation.

Fire apparatus having a gross weight of 16,500 lb., equipped with one of these engines, will accelerate from a standing start to 30 m.p.h. in 8 sec. and attain a speed of 84 m.p.h., averaged for both directions. One of our pumpers recently completed a coast-to-coast demonstration trip, covering 15,101 miles, with an additional 116 hr. of pumping. This engine, with absolutely no adjustments and not a valve ground or carbon cleaned since starting the trip, showed 240 b.hp. on the dynamometer when it was returned to Elmira.

The engine herein described has exceeded the original specifications in every particular and conclusively establishes this type of engine as meeting the needs of modern transportation.

Bearing Investigations Needed

THERE have been instances of the same bearing material being used with tremendous variation in results according to the character of the bond. Experience has shown also that consistent bearing failure can be converted to continuous operation by lowering the oil temperature alone.

How factors such as these can be introduced into a formula we do not know, but it is increasingly evident that both the pv ratio and the ZN/p ratio are wholly inadequate. Perhaps a potential pv value in the form of an allowable combination for a given set of conditions may be acceptable until investigators can embody load, velocity, temperature, material and bond factors in a digestible formula.

A great opportunity exists for bearing investigators to serve this industry. Tests should be conducted under the following conditions: with a varying directional load, with a predetermined flexure of the supports to stress the bond as well as the oil film, and at loads and speeds equal to those used in operation.—From Annual Meeting paper by Alex Taub, M.S.A.E., development engineer, Chevrolet Motor Co., Detroit.

Team Work in Research

By Maurice Holland[1]

Annual Meeting Address

PROBABLY research, as much as anything else, has made it possible for a totally different industry to compete successfully for part or even all of the business of some other industry. Examples of this are at every hand.

This new competition, in turn, has necessitated cooperation among former competitors in the industry threatened. Where this new competition has been of domestic origin, old competitors have been forced to combine, and through their association they have undertaken cooperative research, advertising and marketing in an effort to save their industry from extinction.

Fortunately, a comparative record of the successful operation of cooperative research in different fields of industry has just been made available. In a survey of 200 representative trade associations recently made by the Division of Engineering and Industrial Research of the National Research Council, data were compiled on amounts spent on research, the types of problems selected and the agencies utilized. The results of this survey, supplemented by extensive experience of the Division in this field, are described in a chapter on Trade Association Research by William Spraragen[2].

Research has made it possible for an industry to compete successfully for the business of some other industry.

This new competition has forced former competitors in the industry threatened to combine through their association to undertake cooperative research, advertising and marketing.

Research is listed as an association activity of at least 70 industries. The amount spent annually on research by trade associations has been estimated at about $15,000,000.

The author estimates that spent by the entire automobile industry, which does an annual business of $3,000,000,000, at about $10,000,000, which is less than ⅓ of 1 per cent of sales.

Just under $30,000 a year is spent on cooperative research under S.A.E. supervision.

Research dollars are the premium on a policy on industrial life.

The 1932-model automobile is a dressed-up modern girl running around on a chassis not radically different from those of the "gay nineties." It is about time for revolution by research to step into the picture.

The return on the research dollar is one of the best investments in industry today. Documentary evidence shows a return of from 5 to 15:1 for every dollar spent on research in several fields of industry.

Association versus Private Research

When research is mentioned as a possible trade-association activity, one of the first questions asked is: Does not research properly belong to the province of individual companies rather than to the association itself? Some types of problems should be studied by the individual companies and others by the association. In general, those problems which are common to a number of companies should be attacked by the association, thus eliminating unnecessary duplication and reducing the cost of the investigational work to any one company. Combining the experience and knowledge of a number of companies tends to increase the chances of a successful solution. Also, research on some problems of a fundamental nature is too expensive to be undertaken by one company. These and others involving studies over a period of years, or those dealing with matters of public relations, should be conducted by the association. Others which relate to patentable discoveries, special processes and items of a similar nature can be carried out better by individual companies than by cooperative research.

The argument has sometimes been raised that industrial research should be conducted and supported by a single manufacturer, thus stimulating competition. In such cases the laboratory has advertising value. A research laboratory is a quality guarantee which promotes confidence among the customers of the particular company. Assertion is also made that the laboratory often serves as a school for the training of skilled employes who may be used in other branches of the company organization. Finally, it is claimed that the private laboratory may be entrusted with secrets of great value, especially in the development of new products and methods.

All of these arguments are valid, but they should be considered as arguments favoring the use of private research rather than in opposition to the conduct of cooperative research.

One of the alleged handicaps to cooperative research is the notorious slowness of committee activities. This has been largely overcome by providing paid full-time or part-time services of suitable executive secretaries or directors for each committee.

Research in technical societies and often in trade associations usually is planned and sometimes carried out by committees of the society or association; sometimes by joint committees of two or more organizations. This often has the advantage of bringing the user viewpoint to this investigational work.

The selection of a research committee in an association is an exceedingly important matter. The committee must be composed, not only of technical men, but also of executives and should represent the interests of the small as well as the large companies and also the user viewpoint. Actual selection of the men should be based upon their attitude toward research. In several inves-

[1] M.S.A.E.—Director, Division of Engineering and Industrial Research, National Research Council, New York City.

[2] See Profitable Practice in Industrial Research, published by Harper & Brothers, New York City.

tigations with which I am familiar considerable loss of funds, time and effort has resulted from the appointment of a so-called "practical" research committee which insisted that the investigation be carried out to simulate service conditions. This often involves a number of variables beyond the control of the investigators; in fact, the danger that the program will include problems of this nature is greater in cooperative research than in the private laboratory. Cooperative research must have for its purpose a utilitarian objective, but this should not be confused with undertaking practical problems involving so many variables that they cannot be definitely controlled.

It is not surprising that some of the largest companies in industry are staunch supporters of cooperative or trade-association research as a supplement to their own investigations. These larger companies look upon the group research movement as helpful to them in solving broad problems of common interest to the whole industry, in raising standards of quality and often in instilling greater confidence in the results of the investigation among the public at large.

The attitude of the smaller companies toward cooperative research is somewhat different. By grouping themselves together they can solve problems that are beyond their own private means and can share in the benefit of fundamental knowledge obtained. Even here, however, I do not wish to imply that cooperative research can take the place of individual effort.

Representative Types of Research Organization

A number of industries and associations maintain their own laboratories. This requires a large initial outlay as well as time for the organization to settle down to efficient operation. Others farm out their problems to commercial consulting laboratories. A third plan is to maintain fellowships or retain directly the industrial research staffs whose services are offered by more than 100 universities throughout the Country. A large number utilize the facilities of various Governmental departments such as the Bureau of Standards. Highly complex scientific problems require trained scientific men and often special laboratory equipment and apparatus. Some mechanical processing problems require facilities of shops and manufacturing plants under the guidance of trained observers.

Although the names of some 20 or 30 large educational institutions appear most frequently in reports of trade associations as cooperating in their research activities, some excellent results have been obtained in a number of smaller universities. Actual selection in specific instances depends upon the standing of individual faculty members, special equipment, geographical location and, in a lesser degree, upon financial arrangements.

Research is listed as an association activity of at least 70 industries. The amount spent annually by trade associations on research has been estimated at about $15,000,000. The amounts for individual associations range from a few hundred dollars to more than $200,000 per year. The National Canners' Association, which is representative of one of the largest, oldest and most efficiently managed industries, has one unique feature. It actually took research into the field of consumer operation. It has "a laboratory on wheels," an example that might well be emulated by the automobile industry.

The canning industry is composed of relatively small units, and the modern tendency is to locate canning plants in communities where the raw products can be grown most advantageously. This has resulted in a wide distribution of the industry. Some of the problems of these canning plants can be studied satisfactorily by a distant laboratory; others can be studied only by a laboratory on the spot. Wide and constant touch with canning-plant problems has not only been found an aid to the laboratory in the direction of its fundamental research work, but also makes easier the provision of individual service to canners. How to move the laboratory and its staff from the scene of one operation to another was solved by equipping a laboratory on wheels, which started on its journey in the summer of 1928. On board it were two bacteriologists, an engineer familiar with canning machinery and a technician. Operations finished at one point, they moved to another, and in the course of the season a number of widely separated States were covered.

Another illustration of successful cooperative research is that of the American Bureau of Welding, which is composed of representatives of the major engineering and scientific organizations interested in welding, with suitable representation from the industry. The fundamental research work is carried on in various educational institutions scattered over the United States and is financed by contributions of cash and services from the industry as may be needed for specific investigations. The Bureau assists in formulating problems selected for study, in supplying specimens as may be needed under conditions required by the laboratory, and also in furnishing apparatus and funds when needed. Each university undertakes some fundamental problem with only a few variables which it can control. Although started in many instances with no commercial application in mind, many of these studies have been of far-reaching importance to the industry.

As an example of practical investigation, the work of the structural-steel welding committee of the Bureau is cited. This committee secured the cooperation of 39 fabricating shops, 24 testing laboratories and 3 steel mills in the testing of several thousand specimens with the object of securing fundamental design data. The results have led to the adoption of welding in the building codes of more than 125 cities.

Research in the Automotive Industry

Now let us consider the research picture in the automotive industry. It is a motion picture. The plot is dynamic; it has drama, romance and even mysteries. But from where I stand it appears to be a "talkie"; it is mostly concerned with sound effects, with little or no action. I am speaking now about cooperative research in the interest of the industry as a whole. I admit that several of the large companies have excellent private laboratories; 96 of them in fact[3], but aside from a few of the large companies which are conducting research, most of these appear to be development, testing and "trouble-shooting" departments going highbrow with that much abused name, "research." How do I know? By an examination of the classification of personnel, the laboratory equipment and the type of problems listed under functions. Engineers, chemists and metallurgists figure prominently, with an occasional physicist almost

[3] See National Research Council Bulletin No. 81, listing under Automotive Vehicles, Equipment and Accessories.

lost among the privates in the research army who rate as technical assistants, while Ph.D's are as scarce as horseflies in Detroit!

So far as I am able to learn, no figures are available on the total annual expenditures for research for the automobile industry. From a cross-section sampling of 20 representative automobile manufacturing companies, large and small, the average laboratory personnel numbers 50. With this single factor as a basis for a rough approximation, I should estimate the annual total expenditures for research for the industry at something like $10,000,000. And this for research for a $3,000,000,000 industry! Less than ⅓ of 1 per cent of sales. What would you think of a man who carries ⅓ of 1 per cent insurance on his house? Research is industrial insurance against competition. Research dollars are the premium on a policy on industrial life or death.

The general average of research expenditures of all industry is 1.3 per cent of capital investment. This figure is based on a survey of nearly 1000 representative manufacturing companies rated at $1,000,000 or more. No authentic data on annual expenditures for advertising by the automotive industry seem to be immediately available, but from what meager information I could secure I hazard the guess that it is on the order of $100,000,000. That is interpreted by me to mean that 10 advertising dollars to 1 research dollar are spent in chasing the consumer's dollar, overcoming sales resistance and selling him a car that will be paid for when the sign of the bull is in the heavens over Wall Street again!

Fortunately, actual figures on the expenditures for cooperative research are available. Just under $30,000 a year is now being spent on cooperative research under S. A. E. supervision. If additional sums are being spent on cooperative research through other agencies I am not aware of it. Now $30,000 for cooperative research for a $3,000,000,000 industry is less than the proverbial drop in the bucket. The chart in which the expenditures for cooperative research by 38 leading trade associations are listed puts the automobile industry in a class with the Western Red Cedar Association, the Glass Container Association and the Malleable Iron Research Institute. In the research race for industrial supremacy the automobile industry noses out the Biscuit and Cracker Manufacturers and the Dyers and Cleaners Associations by $5,000, but takes a terrible beating from the California Fruit Growers and National Lumber Manufacturers Associations and the American Petroleum Institute, which are in the big-money class.

From these illustrative comparisons the automobile industry appears as a private in the rear rank in the big parade of modern-science-aided industries. This may seem to be a paradox when the business and engineering headaches of last year were translated into Automobile-Show headlines, and the 1932 models made their bows to "their public."

Strip off the make-up of color, tinsel and gadgets; pull out the padded upholstery and scrap the chromium-plated hardware, and we see the modern automobile as a synthetic product of the combined research of a hundred industries and with the heritage of science extending back to Faraday, Otto, Priestly and a host of others. If, as some authorities contend, the present-day motorcar is made possible by rubber, alloy steels and petroleum, I hardly need to mention the distinguished generals of science leading an army of research workers that the mere mention of these three materials brings to mind.

In the last analysis, the present-day automobile is a research assembly job. The 1932 model, with its new finery, is a dressed-up modern girl running around on a chassis not radically different from those of the "gay nineties." Essentially, the process has been one of gradual evolution. It is about time for revolution by research to step into the picture, and by research I mean the kind of revolution that produced synthetic silk which rivals nature's product, that made a $600,000,000 industry out of a formula developed by Maxwell, that brought helium gas down from the heavenly bodies to fill dirigibles which cross continents and span the seven seas, and the kind of modern magic that produced another $3,000,000,000 industry in less than 50 years when Bell invented the telephone.

Being forward-minded individuals working in research-minded industries, let us gaze into the crystal of the future and picture a 1940 model. I seem to see a low streamlined model representing the dynamic power that propels it, perhaps by sources of energy and mechanisms unknown today. It can be operated by a child, perhaps with a single lever, and its speed controlled by a deft touch of the hand. Hardly a vestige of the old-fashioned 1930 model remains. How is this to be brought about? The magicians who transformed that 1920 model to the present-day car, working with the tools of research, will produce an automobile for the customer of 1940 that will be as much or more of an advance than has been made in the last decade.

What are these prospectors on the frontiers of the automotive industry doing to blaze a trail leading to that 1940 model? Among other cooperative research projects listed in the latest S.A.E. Research Committee report are detonation, vapor lock, sulphur and gum content, Diesel fuel, lubricants, front-wheel alignment, riding comfort and highways. It looks to me as though the automotive industrial explorers are already blazing a trail that will lead to the fuel of the future. However, I am disappointed to see so little attention directed toward the automobile itself. Let us again get out our cooperative-research yardstick for a final appraisal of a research program that will meet the ambitious ideals which we have set up.

Selecting Subjects for Study

The selection of any program for study should be pursued with care. Some problems will be found to be of such a nature that they will yield results in a reasonably short time and thus provide against the possibility of condemnation by more impatient members of an association. But the program should include, if possible, problems of a fundamental as well as a practical nature.

Before a project is undertaken, certain yardsticks should be applied, such as

(1) Is the project really important?
(2) What are the prospects of success?
(3) Has it been done before?
(4) Are the resources of time, money and personnel available for successful completion?

Some problems require for their complete solution a period of years and, unless careful financial provisions are made for completing the work undertaken, considerable sums of money may be wasted, since the prepara-

tory work can seldom be translated into profitable use. Some problems should be of such a nature that usable results can be obtained after a period of one year, others perhaps after a period of two years, and still others after three or more years. In this way, continued confidence in the work would result, particularly on the part of some of the more impatient members.

It is suggested that a thorough survey be made of the more important chronic technical problems hindering the progress of the industry from the point of view of their importance and the time element involved in their solution.

One of the great difficulties in conducting a research program arises from the temptation of everyone having trouble of any kind to bring it to the laboratory for solution. The laboratory is thereby turned into a "trouble-shooting" agency rather than a research organization. Some investigations undertaken by the research laboratory may properly arise as a result of troubles, but it is undesirable that the major part of the program be given over to development problems. Some trade associations have two separate departments, one to take care of technical problems, another for service problems.

Cooperative Fuel-Research Project

At least a good start has been made with the cooperative fuel-research project that is being carried out under the joint auspices of the Society, the National Automobile Chamber of Commerce and the American Petroleum Institute. That project measures up to our yardstick of appropriate cooperative research projects on at least four counts. Two industries saw the handwriting on the wall and recognized the present tendency in which cooperation, not competition, is the life of trade. The public probably was agreeably surprised to note the extended helping hand of service raised, not against it, but in support of it and its modern means of locomotion.

The return on the research dollar is one of the best investments in industry today. We have documentary evidence of a return of anywhere from 5 to 15:1 for every dollar spent on research, as reported by executives from several fields of industry. Surely research needs no further proof to establish the fact that it is a paying investment.

The cooperative fuel-research project is, however, just a good start. A number of other equally important fundamental problems which affect the industry as a whole are lying dormant and ready to be raised by the levers of applied science. If I may conclude with an illustration of some practical reactions which I heard expressed in connection with the new models at the recent automobile show in New York City, I could not do any better than to ask the questions which C. F. Kettering asked in his recent excellent article[4] when he inquired: "Are we going on building up the American industrial machine, or are we simply going to operate it?" and "What are you going to do when you can't keep on doing the things you are doing now?"

With the traffic and parking problem in most American cities completely at a standstill, a car capable of an 80-m.p.h. speed must have been designed for Texas Rangers. With all the developments in new alloys, we ought to have a lighter-weight car which might contribute to fuel economy. We might have one built of stronger and tougher steels as an additional safety factor; and certainly a smaller car would be convenient for dodging in and out of traffic and for parking.

With 50 per cent of the street space in New York City taken up by cruising taxicabs, the Police Department recently promulgated a regulation that will prohibit cruising and require the cabs to be stationed at specified stands. A cooperative research on the economy of size of certain types of motor-vehicle might offer a possible solution of the traffic problem.

I am privileged to offer the services of the Division of Engineering and Industrial Research of the National Research Council, backed by 10 years of experience in all fields of research organization, as research adviser to the automotive industry through the Society of Automotive Engineers. We can, and shall be glad to, assist in the formulation of a program, the selection of research agencies and in providing contacts with the world of science in industry, both in this Country and through foreign correspondents, in practically every technical and research center of the world.

[4] See Industry at the Crossroads, *Saturday Evening Post*, Feb. 26, 1931.

The Compression-Ignition Engine

IF we consider the direction along which the development of the gasoline engine has progressed, we see that the simplest form has survived. All of those forms involving variable compression ratios and the like have passed away. The gasoline engine of today is the gasoline engine of almost 20 years ago except for improved materials and fuels and more scientific design of the combustion chamber.

Why should not the same cycle of events occur with the compression-ignition oil engine? In a few years this engine will consist of a cylinder, piston, valves and an injection system. Performance of the engine undoubtedly will be far superior to that of the present engines but solely because of our greater knowledge of injection and combustion.

The fact that this type of engine has a greater thermal efficiency than has a gasoline engine is unquestioned, yet 99 out of 100 persons think that an oil engine should develop less power for a given set of conditions than does the gasoline engine. As both types are air engines, their air consumption in conjunction with the thermal efficiency should determine the power output, and on this basis the oil engine should give substantially more power than the gasoline engine. Up to the present, this additional power output has been secured only in isolated cases, and those chiefly of an experimental nature. The usual fuel system fails to supply the necessary atomization, distribution and the like at a brake mean effective pressure of about 100 lb. per sq. in. To what extent this is affected by air turbulence is difficult to estimate, but the power of those engines possessing the maximum of turbulence, usually produced by restriction during compression, begins to fall away at lower mean pressures than does that of those relying upon no particular air motion other than that occurring as a result of valve action. Again, Ricardo has shown that a definite value seems to be associated with his particular injection system which gives the maximum results. The building of a satisfactory compression-ignition engine therefore resolves itself into eliminating as many useless parts as possible and carrying the chemical combination of the fuel and the air to the extreme limits but maintaining accurate control of this process at all stages.—From a Detroit Section paper by E. T. Vincent, Diesel research engineer, Continental Motors Corp., Detroit.

Automotive Research

Extreme-Pressure Lubricants

Problem and Research Program of Subcommittee —Summary of General Survey

THE Lubricants Research Subcommittee of the Society was organized in June, 1931, "to study the relation between lubricant characteristics, operating conditions and design factors under high pressures, and to develop adequate test methods for extreme-pressure lubricants which will be significant as regards service conditions, including bearings and other parts of the mechanism subjected to the same lubricants."

The Committee states its general problem as follows:

Work done by a number of organizations indicates that four of the more important properties of extreme-pressure lubricants are:

(1) Load-carrying capacity before seizure
(2) Tendency to cause wear or abrasion
(3) Corrosiveness
(4) Stability both in storage and in service

Obviously, the load-carrying capacity should be investigated first, since the other properties are of no consequence if the lubricant will not stand the desired load. Accordingly, the detailed program that follows is based on an initial study of this phase of the investigation with due regard to the other phases which are a necessary part of any complete investigation of extreme-pressure lubricants and will be considered in more detail at a later date.

(1) Measurement of the load-carrying capacity of representative types of lubricant, to be selected by the Oil Group, with the General Motors, the Timken and other machines, following the procedure recommended by the designers
(2) Correlation of these data with actual service performance
(3) Development or recommendation of a significant and practical test machine and procedure

Summary of Findings and Plans

In the last nine months a general survey has been made to determine what information is available on this subject and the foregoing program outlined to carry on the work. The purpose of this report is to summarize briefly the findings of the Subcommittee and the plans to investigate this problem.

Research work in independent laboratories showed that certain lubricants prevented scoring and galling of gears in a hypoid rear axle, under operating conditions that would cause failure with conventional mineral oils and greases. Further investigation showed that other types of gear unit operating under conditions such that the gear teeth were scored or galled were, in many cases, satisfactorily lubricated with these special lubricants. The term "extreme-pressure lubricants" has been applied to such products.

A large portion of the original work, some of the results of which have been published, was done by the Gleason Works, the General Motors Corp. Research Laboratories and the Timken Roller Bearing Co.

It soon became obvious that extreme-pressure lubricants were of general interest, and testing work has since been started by manufacturers of gear-sets, antifriction bearings, axles and transmissions, automobiles, commercial vehicles and lubricants; also by operators who use the products of these manufacturers.

The independent work of these investigators has been very valuable, resulting in a number of laboratory testing machines for evaluating extreme-pressure lubricants and the accumulating of considerable information on the subject.

Types of Test Machine Built

A number of different types of special test machine have been built by concerns interested in the problem. The best known of these are the General Motors abrasion-test machine[1] and the Timken Roller Bearing Co.'s oil-testing machine[2]. The following brief outline of their design is given only to illustrate machine types:

In the General Motors machine, a hardened-steel shaft rotating in a bath of the test oil is loaded to 25,000 lb. per sq. in. or more, through a hardened-steel bushing. The performance of the lubricant is judged by the load carried before seizure occurs, or, if no scuffing occurs, by the frictional load and the condition of the parts. Other machines using smaller shafts and different methods for the rubbing parts have been developed and are in use.

In the Timken machine, a small square block of hardened steel is forced into contact with the outer surface of a Timken bearing cup, which is rotated on a shaft. Loads and speeds can be varied within a wide range, but it is customary to judge the value of a lubricant by the load it carries, at a selected rubbing speed, without scuffing of the test block. The amount of wear and the friction are also considered.

Other types of test machine include rotating discs with face or edge contact, small gear-sets, and so forth. New types are under development at present. While most of the machines are being used for research work or factory test purposes, some are being employed in the field to demonstrate the value of commercial extreme-pressure products.

The most notable fact developed by comparison of the results obtained with the various test machines using identical lubricants is an astonishing lack of agreement among machines in the rating of individual products. Further, the divergence in results is even more marked when service experience is taken into consideration.

In brief, it may be said that today no available test machine or method will rate correctly the extreme-pressure characteristics of all of the different types of lubricant as shown by their performance in service.

The Lubricants Research Subcommittee, made up of representatives of all the industries involved, has given consideration to all of the data available, and the situation at present seems to be as follows:

(1) Lubricants are available which are effective in gear-sets and bearings at higher loads than those at which ordinary mineral oils and greases are effective. Several such lubricants appear to be satisfactory.
(2) Many gear-sets and bearings are capable of operating at higher loads when extreme-pressure lubricants are used than when ordinary lubricants are used. The exact conditions under which such lubricants are required is not known, nor is the effect of different metals on this requirement known. Indications are that, under conditions where conventional oils and greases are satisfactory, nothing is to be gained by using extreme-pressure lubricants.
(3) Results obtained on different laboratory testing machines vary considerably, so there is no standard method for evaluating extreme-pressure lubricants.
(4) Final conclusions as to properties of extreme-pressure lubricants can be reached only by carefully observing the results obtained in the units to be lubricated. Most of the test machines give an indication of properties of the lubricants but cannot be relied upon to check each other or indicate the essential properties of the lubricants.

Bureau to Conduct the Work

It is very important to have available a test method by which to evaluate extreme-pressure lubricants, that is, to provide a "yardstick", so that the refiner can make lubricants having the necessary properties and the user can specify such lubricants if desired.

The work of the Subcommittee is to be carried on by the Bureau of Standards, under the supervision of the Subcommittee, and will correlate any data made available by members of the Subcommittee.

It is estimated that the desired information on the most important phase of the work—load-carrying capacity—can be obtained in one year. This research is to be financed by individual contributions from the industries interested.

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[1] Paper presented at the 12th Annual Meeting of the American Petroleum Institute, Nov. 12, 1931.

[2] See S.A.E. JOURNAL, January, 1931, p. 53.

Standardization Progress

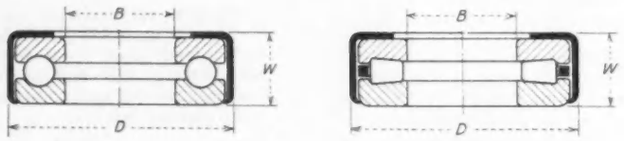
Steering-Knuckle Bearings

Ball and Roller Bearings Division of the Standards Committee Proposes Revised Standard

WHEN the Society adopted an S.A.E. Standard for thrust ball-bearings 15 years ago, the steering-knuckle type represented the concensus of opinion of bearings manufacturers regarding a logical standard, but apparently it was not used to any extent by the vehicle manufacturers. This standard is shown on p. 318 of the 1931 S.A.E. HANDBOOK.

About four years ago the formulation of international standards for thrust ball-bearings was under consideration by the Division and, in reviewing American practice, the Division decided to review all the S.A.E. specifications for thrust bearings. Therefore a Subdivision was appointed, with H. N. Parsons as chairman, which reported a suggested new standard after consulting with the bearings manufacturers. Owing to circumstances that developed, a new Subdivision was organized later, with Ernest Wooler as chairman. The accompanying tentative proposal is submitted as a majority report after further study of the requirements for this type of bearing as indicated by the current practice of bearings manufacturers. The report includes bearings of both the ball and taper roller types which are interchangeable and which the majority of the Subdivision feels will adequately meet automotive requirements.

The report is published in this issue of the S.A.E. JOURNAL for review by the automotive industry at large and with the request that any constructive suggestions regarding the report be returned to the Standards Department of the Society promptly, so that they can be considered by the Subdivision and the Ball and Roller-Bearings Division before submitting the report to the Society for adoption at the Semi-Annual Meeting next month.



Bearing Number and Nominal Pin Diameter	*B* Bore[a]		*D* Outside Diameter, Tolerance +1/64, -0	*W* Width, Tolerance +1/64, -0
	Minimum	Maximum	In.	In.
5/8	0.627	0.640	1 5/8	1/2
11/16	0.6895	0.7025	1 5/8	17/32
3/4	0.752	0.765	1 5/8	17/32
13/16	0.8145	0.8275	1 21/32	17/32
7/8	0.877	0.890	1 57/64	19/32
15/16	0.9395	0.9525	1 57/64	19/32
1	1.002	1.015	2	5/8
1 1/16	1.0645	1.0775	2	5/8
1 1/8	1.127	1.140	2 3/16	5/8
1 3/16	1.1895	1.2025	2 3/16	5/8
1 1/4	1.252	1.265	2 3/16	5/8
1 3/8	1.377	1.390	2 5/8	3/4
1 1/2	1.502	1.515	2 55/64	27/32
1 5/8	1.627	1.640	2 55/64	27/32
1 3/4	1.752	1.765	3 17/64	15/16

[a] The minimum and the maximum bore dimensions for bearings with the same bore in both rings. For bearings with the bore of one ring closely fitted, use the minimum dimensions shown; other ring bore to have a maximum clearance of 1/32 in. for element of self-alignment.

Proposed Extension of Sizes of Poppet Valves

AMONG the subjects for standardization that were taken up by the Diesel-Engine Division of the Standards Committee was the extension of the S.A.E. Recommended Practice for poppet valves, p. 81, 1931 S.A.E. HANDBOOK, to include sizes above 3-in. diameter for Diesel-engine application. Harte Cooke was appointed a Subdivision and prepared the accompanying recommendation for valve sizes 3 1/8 to 6 in. inclusive.

The report is accordingly published at this time to give all Diesel-engine and valve manufacturers an opportunity to review it before the report is referred to the Standards Committee and the Society for adoption at the Summer Meeting in June. It has already been reviewed by a number of the Diesel-engine manufacturers, who indicated its acceptability. It is felt that it should be reviewed and constructively criticized in the light of a general standard rather than from the viewpoint of any particular manufacturer's practice. Manufacturers who desire to so comment on the report should do so to the Standards Department of the Society not later than the middle of May so as to give the Division opportunity to review such criticisms before the final report is submitted to the Society for adoption.

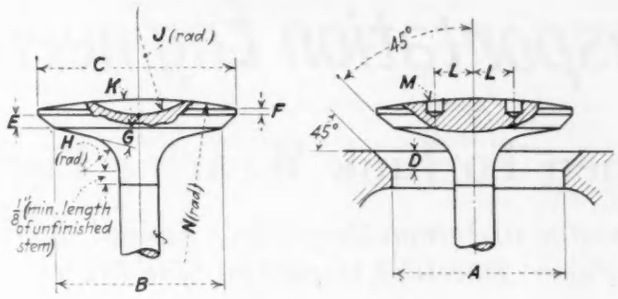


TABLE 1—VALVE-HEAD EXTENSION DIMENSIONS

Nominal Size A	B	C	D	E	F	Deg. G	H	J	K Width	K Depth	L	M Diameter	M Depth	Radius
3 1/8	3 2/32	3 17/32	5/32	7/32	1/8	12	3/4	1 3/4	1/8	5/32	3/4	1/4	1/4	10
3 1/4	3 7/32	3 21/32	5/32	7/32	1/8	12	3/4	1 3/4	1/8	5/32	3/4	1/4	1/4	10
3 3/8	3 11/32	3 25/32	5/32	7/32	1/8	12	3/4	1 3/4	1/8	5/32	3/4	1/4	1/4	10
3 1/2	3 15/32	3 31/32	3/16	1/4	3/16	12	7/8	1 3/4	1/8	5/32	3/4	1/4	1/4	10
3 5/8	3 19/32	4 3/32	3/16	1/4	3/16	12	7/8	1 3/4	5/32	3/16	7/8	1/4	1/4	12
3 3/4	3 23/32	4 7/32	3/16	1/4	3/16	12	7/8	1 3/4	5/32	3/16	7/8	1/4	1/4	12
3 7/8	3 27/32	4 11/32	3/16	1/4	3/16	12	7/8	1 3/4	5/32	3/16	7/8	1/4	1/4	12
4	3 15/16	4 1/2	3/16	9/32	1/4	15	1							15
4 1/4	4 3/16	4 3/4	3/16	9/32	1/4	15	1							15
4 1/2	4 7/16	5 1/16	7/32	5/16	1/4	15	1							15
4 3/4	4 11/16	5 5/16	7/32	5/16	1/4	15	1 1/4							20
5	4 15/16	5 9/16	7/32	5/16	5/16	15	1 1/4							20
5 1/4	5 3/16	5 13/16	7/32	5/16	5/16	15	1 1/4							20
5 1/2	5 7/16	6 1/8	1/4	11/32	5/16	15	1 1/2							25
5 3/4	5 11/16	6 3/8	1/4	11/32	5/16	15	1 1/2							25
6	5 15/16	6 5/8	1/4	11/32	5/16	15	1 1/2							25

Valves 4 in. in diameter and larger should be made of materials that have high heat-resisting properties.

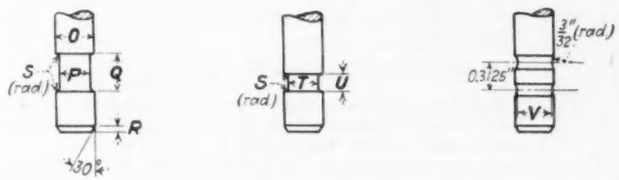


TABLE 2—VALVE-STEM EXTENSION DIMENSIONS

Nominal Size A	O Maximum	O Minimum	P Maximum	P Minimum	Q Maximum	Q Minimum	T Maximum	T Minimum	U Maximum	U Minimum	V Maximum	V Minimum
3 1/8	0.686	0.684	0.562	0.555	0.687	0.681	0.500	0.493	0.250	0.244	0.593	0.588
3 1/4	0.686	0.684	0.562	0.555	0.687	0.681	0.500	0.493	0.250	0.244	0.593	0.588
3 3/8	0.686	0.684	0.562	0.555	0.687	0.681	0.500	0.493	0.250	0.244	0.593	0.588
3 1/2	0.749	0.747	0.625	0.617	0.750	0.742	0.546	0.538	0.281	0.275	0.656	0.651
3 5/8	0.749	0.747	0.625	0.617	0.750	0.742	0.546	0.538	0.281	0.275	0.656	0.651
3 3/4	0.874	0.872	0.718	0.710	0.875	0.867	0.625	0.617	0.312	0.306	0.750	0.745
3 7/8	0.874	0.872	0.718	0.710	0.875	0.867	0.625	0.617	0.312	0.306	0.750	0.745
4	0.999	0.997	0.843	0.835	1.000	0.992	0.718	0.710	0.375	0.368	0.875	0.869
4 1/4	0.999	0.997	0.843	0.835	1.000	0.992	0.718	0.710	0.375	0.368	0.875	0.869
4 1/2	0.999	0.997	0.843	0.835	1.000	0.992	0.718	0.710	0.375	0.368	0.875	0.869
4 3/4	1.123	1.119	0.937	0.927	1.125	1.115	0.812	0.804	0.421	0.414	0.937	0.931
5	1.123	1.119	0.937	0.927	1.125	1.115	0.812	0.804	0.421	0.414	0.937	0.931
5 1/4	1.123	1.119	0.937	0.927	1.125	1.115	0.812	0.804	0.421	0.414	0.937	0.931
5 1/2	1.248	1.244	1.062	1.052	1.250	1.240	0.937	0.927	0.468	0.460	1.062	1.055
5 3/4	1.248	1.244	1.062	1.052	1.250	1.240	0.937	0.927	0.468	0.460	1.062	1.055
6	1.248	1.244	1.062	1.052	1.250	1.240	0.937	0.927	0.468	0.460	1.062	1.055

Transportation Engineering

When To Junk Wearing Parts

Discussion of Joseph Geschelin's Annual Meeting Paper[1] Develops Important Side Lights

MAJOR points brought out in the discussion of this paper are stated in abstract form herein, publication of complete details having been prevented by lack of available space.

A. F. Coleman[2] mentioned that, where a maximum tolerance is matched up with a minimum tolerance, the so-called wear life already may have been lost. The manufacturer will therefore need to be more careful in assembling parts if this is to be avoided. He agreed with Mr. Geschelin that, in the repairing of motor-vehicles, the variable human element probably is one of the most serious difficulties, but pointed out that to drag equipment into the service stations throughout the Country continuously to test the clearances with precision instruments so as to make the minor repairs would be expensive because the equipment must be torn down to gain access to the most essential parts. Most repairs are made in the field; major repairs, made in general shops, would be facilitated by the precision instruments.

Referring to maximum boring dimensions for reboring cylinders, Mr. Coleman said that, for example, Pratt & Whitney air-cooled engines are tooled all over so that the manufacturer knows the exact thickness of the cylinder-walls before the job leaves the factory and can specify maximum reboring cuts; but the truck-engine and the car-engine manufacturers merely assume that they know the thickness of the cylinder walls, the walls being cored on the outside and not machined, so that, in second and third reboring jobs, the wall may become too thin, the engine may overheat and so on.

Operating Conditions an Important Factor

M. D. Munn[3] wrote in part that there is need for the manufacturer to supply service organizations with definite repair standards. The actual repair man should have available a readily accessible table or tables of clearances to guide him in refitting and adjusting parts. Many good workmen are today wasting operating dollars in an attempt to secure minimum operating clearances that are unnecessary if the function of the part were properly understood. More information is needed by the service man on the handling of heat-treated parts, as in too many cases heat is used in straightening them, a practice that often results in complete failure of the re-worked part in service.

One of the serious difficulties that will be encountered in setting up clearances and wear limits as measured by clearances, Mr. Munn continued, will be the interpretation that will need to be made to provide for wide differences in operating conditions. This can be illustrated with the clearance of the piston skirt and cylinder bore. In the case of an engine that is seldom speeded beyond 1500 r.p.m. except when accelerating in gear, a skirt-to-bore clearance of 0.010 in. or more is possible before oil consumption becomes a real factor in the operating cost; whereas the identical engine used in a service requiring maximum engine speed a high percentage of the time may require refitting when the added clearance exceeds 0.005 in. In other words, it will not be possible to say definitely that a production clearance of a certain figure may be worn to some definite wider clearance and expect to have this stand except for some assumed case.

A System of Tolerances Outlined

W. L. Hindman[4] deduced from the 1931 maintenance figures quoted in the paper that Mr. Geschelin is asking automotive engineers to help develop a technical tool that is badly needed for a business representing approximately $40,000,000,000. If a modern factory having a machine costing $3,000 needed a mechanical tool or attachment to make the original machine more efficient and which would cost $3, or 0.1 per cent of the value of the machine, he stated that he felt safe in saying that no progressive management would refuse to furnish the tool.

Mr. Hindman predicted that a system of tolerances which stands for the following requirements will be as valuable to the engineer in the years to come as are our present tables of sines and cosines. Such a system must (*a*) encourage the use of present standard hole-finishing tools such as reamers and broaches; (*b*) tend to give maximum economy from these tools both when new and when salvaged; (*c*) recognize the necessity for, and include as a part of the system, special holes and fits for various purposes which are comparable to minutes and seconds in trigonometric functions; (*d*) supply a reasonable range of standard holes and shafts and (*e*) provide an identification of all fits.

With such a system in general use, stated Mr. Hindman, engineers will be able to work on a common basis and acceptable factory standards can then be set up for various priced cars and trucks. An expert on fits with one company has much to unlearn and still more to learn in a different way the moment he joins another organization, which is perhaps the main reason that no general set-up of tolerances and fits has been developed to which all concerned can refer and get the same answer or a close approximation to it. Solution of the problem presented by Mr. Geschelin hinges, basically, on the development of these same acceptable standards, asserted Mr. Hindman, who feels confident that, if those on whom the burden of responsibility rests see the urgent necessity for starting this work, it can be mastered in a reasonable time and at a reasonable cost.

Operating-Cost Curve Discussed

J. G. Moxey[5] said in part that some trucks in his company's fleet have been in active service for a number of years and their operating-cost curve is of saw-tooth form. The curve for a new truck shows gradually rising cost up to a point that indicates need of overhaul, abrupt cost depression afterward and rising cost until the next overhaul. Thus keeping a given truck within the limit of its economic operation for a period of years, he asked what the economic move would be for taking it out of service. He concurred with Mr. Coleman as to the difficulty of applying Mr. Geschelin's plan. Saying that his company originally fell heir to a fleet of 85 trucks of the so-called "reciprocity" type of which it was necessary to scrap 18, he remarked that among the remaining 67 were 14 different makes and sizes—including one fleet of 11 of the same make and size—and asked how any shop or service supervisor can set up a manual of tolerances for maintaining such a fleet. He mentioned also the exorbitant expense of tearing down a truck to determine whether or not to replace some parts.

After a truck has been turned over to a shop foreman in Mr. Moxey's maintenance organization, the foreman is allowed to spend a specified amount of money on his own authority for truck repair; but if, after dismantling for the overhaul, he finds that the cost is likely to exceed that amount, he must obtain authorization to proceed from the central-control supervisor of the fleet. This affords an opportunity for the supervisor to determine whether or not to work out a retirement policy for that truck, based on the return of the investment to the stockholders of the company.

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[1] The paper was published in abstracted form in the S.A.E. JOURNAL, April, 1932, p. 31. Mr. Geschelin is a Member of the Society and engineering editor of *Automotive Industries*, Chilton Class Journal Co., Philadelphia.

[2] M.S.A.E.—Manager, motor-vehicle department, Standard Oil Co., Inc., New York City.

[3] M.S.A.E.—Repair service engineer, White Motor Co., Cleveland.

[4] Consultant on interchangeable manufacturing, Detroit.

[5] Supervisor of motor transport, Atlantic Refining Co., Philadelphia.

Mr. Moxey stated that, in working out any such plan, it is difficult to return money at a greater rate than say 15 to 17 per cent. In his opinion, a shop foreman or chief of inspectors in charge of a series of shops is sufficiently endowed with mechanical knowledge to say "yes" or "no," relative to the use of a part in a newly assembled machine after overhauling. If, in the judgment of the foreman, the part should be replaced, the old part is not scrapped until a committee has determined definitely by micrometers or other means whether it shall be scrapped.

Range of Tolerances Questioned

J. F. Winchester[6] stated that the question of standard tolerances rests largely with the manufacturer, whose engineers have the early-stage development of the vehicle in hand and make and correct the drawings. All tolerances for the different running fits are established when the machine goes into production. Therefore, it seems to Mr. Winchester to be a relatively simple matter to set down the tolerances of the different parts in a handbook or manual and pass it on to the fleet operator. He questioned whether the range of tolerances suggested by Mr. Geschelin would be advisable, in that the manufacturer might take advantage of them and perhaps put into a vehicle many parts that he is now scrapping, with the ultimate result of shortening the life of the vehicle. But he remarked that a good proportion of the decisions about replacement of parts does not altogether depend on a knowledge of these fits; it depends also on the conditions under which the vehicles are operated. To a large extent, it is dependent on education by the supervisor who is in contact with the personnel in his organization. Education should begin with the manufacturer of the vehicle.

Mr. Winchester said further that, if the mechanics in the field or in the shop would study a manual, such as the new Buick Manual that is now available to all transport men, they would have a good understanding of the fundamentals that result in the proper working of the parts in a vehicle. He mentioned the great number of special tools sold for service-station work in the last few years and said that a large percentage of them are lying idle, because either they are unsuitable for the purpose or the mechanics do not know how to use them. He believes that in time the standardization of tolerances and clearances will straighten itself out, and he advised the manufacturers to retain the personnel in their service departments for longer periods of time as an aid in reducing operating costs.

Method of Standardizing Proposed

M. C. Horine[7] reminded those present that wear proceeds in some geometric ratio to increase of clearance beyond the ideal. Therefore Mr. Geschelin's curve of the law of wear should be parabolic throughout its entire length, instead of straight, he said; that is really the key to the problem with respect to the point which indicates that a part should be junked, together with the periodic inspection and overhauling system which is gaining so much favor in maintenance today. In other words, parts cannot be worn out economically because they do not all wear at the same rate. When a number of important parts have worn a sufficient amount, the expensive work of tear-down, readjustment, replacement and rebuilding must be done. At that time a number of parts that have life left in them must be replaced, because the next tear-down will occur at such a remote period that these parts will have insufficient economical wear life. Regarding proposed standards, he suggested that they be confined to clearances and not to sizes and that they be arranged according to units rather than to chassis.

Type of User Is a Factor

A. W. Scarratt[8] said, regarding the life basis on which to figure amortization, that trucks should be divided into two classes, according to the type of user; that is, whether he is a precise and discriminating user or one who is not. A precise and discriminating large-scale operator can maintain his fleet in good order and get practically an indefinite life service out of it, but an operator who does not care for his vehicles in that manner will wear his fleet out in a short while, it being probably fair to say that this type of operator should consider the replacement of his equipment at the end of say 100,000 miles of service.

Assuming that the engineering design is right, continued Mr. Scarratt, in-built quality, which is provided by the manufacturer and plays such an important part in service, consists of four elements: (*a*) quality of the materials, (*b*) physical condition into which the manufacturers work those materials, (*c*) tolerances and (*d*) quality of finish that goes with those tolerances. Each element plays a very important part in how well and how long the parts will render good service. Most manufacturers supply their service organizations with such tolerances as they feel should enable them to rebuild a unit properly, he said, although that may not be just what Mr. Geschelin has in mind, because many large-scale operators of trucks aim to take care of their own service; in such case, perhaps a large-scale operator should have special consideration.

T. C. Smith[9] commended the paper as being particularly valuable in that it is provocative of further thought on this subject before starting any procedure that might ultimately cause great confusion. To be of assistance to maintenance men, a manual giving tolerances should exclude information about methods and tools of diagnosis and other extraneous matter, he said. The book should be small and usable. He feels that the preparation of this information should be along the line suggested by Mr. Horine. He differentiated between blueprint dimensions and tolerances to be used for manufacturing and those that are to be used for maintenance purposes, saying that in the maintenance field two parts are already matched and the information wanted is whether one part, or one part and its mating part, should be replaced; that is, the difference between the two dimensions, rather than to say of one part that it shall wear a certain amount more before being replaced.

Standard Code Vitally Essential

H. V. Middleworth[10] wrote in part that the establishment of more definite methods whereby motor-transport equipment can be maintained efficiently, safely and economically is a great and important problem. To rely upon the recommendations of the skilled mechanic or tester and the judgment of the repairman can no longer be regarded as practical or economical. Undoubtedly, many parts have been replaced long before they had given their safe and economical service; also, he presumed that parts have been kept in service long after they had become dangerously worn.

There can be very little doubt that a sensible, workable code of instructions giving allowable clearances and tolerances is vitally essential, Mr. Middleworth stated, but the burden of establishing such a code obviously would be placed upon the engineering resources of the manufacturers and their service organizations. No doubt the manufacturers possess valuable research data which could be made use of in the preparation of a code of instructions such as proposed by Mr. Geschelin, he continued, although we cannot foretell how far-reaching in effect this proposal may be, nor can we predict the outcome. But whatever is accomplished along the lines proposed, he feels certain will be a step farther toward more safe and economical methods than are now employed in the repairing and maintenance of motor-transport equipment.

B. B. Bachman[11] referred to Fig. 3 of the paper regarding clearances, considering an internal part having a specified tolerance, an external part having a specified tolerance and the zone between the two. This was in connection with running fits, because they are most important from a wear viewpoint. He remarked that it is natural for a workman to hold to a dimension between the minimum and the maximum dimensions, because he would be censured if he exceeded either limit: but, if the clearance were specified, he could protect himself somewhat. If the condition illustrated in Fig. 3 is true, he continued, that is, if the wear life is such a small proportion of the original tolerance, the situation looks bad. But the answer does not lie

[6] M.S.A.E.—Manager, motor-vehicle department, Standard Oil Co. of New Jersey, Newark.

[7] M.S.A.E.—Sales promotion manager, International Motor Co., Long Island City, N. Y.

[8] M.S.A.E.—Chief engineer of motor-trucks and motorcoaches, International Harvester Co., Chicago.

[9] M.S.A.E.—Engineer of automotive equipment and construction apparatus, American Telephone & Telegraph Co., New York City.

[10] M.S.A.E.—Superintendent of operation, transportation department, Consolidated Gas Co. of New York, New York City.

[11] M.S.A.E. — Vice-president, engineering division, Autocar Co., Ardmore, Pa.

in the tolerances; it lies in making the surface hardness such that its wear life within that amount of tolerance will be satisfactory. To illustrate that the situation may not be as bad as it seems, he noted the running fit indicated in Fig. 3 as to the wear value of the valve stem and its guide. The tolerance specified is 0.006 to 0.008 in. loose, which he said is satisfactory and represents the original clearance specified by the manufacturer, with a limit of 0.012 in. Then, if the manufacturer has provided an 0.008 instead of a 0.006-in. fit, he still has left 200 per cent on the original clearance. If he has provided the 0.006-in. fit, the condition is even better.

Pacific Coast Experience Cited

J. C. Bennett[12] wrote that his company has established limits, for its own guidance, corresponding to Items (2), (4) and (5) in the list of seven items presented in the paper. These limits do not necessarily cover all equipment in the fleet and must be used with some discretion, he stated, but he finds that they do serve to clarify many questions which present themselves constantly during the company's operations. He said that his organization is looking forward to the time when it shall be able to establish other limits corresponding essentially to Items (1), (3), (6) and (7) in the list, because the use even of the three factors covered by Items (2), (4) and (5) has enabled it to effect substantial reductions in maintenance expense.

Because of the extent of its fleet, Mr. Bennett continued, the company felt that its own experience justified it in undertaking responsibility for the results of reconditioning an engine only to such extent that it would be expected to return at the end of the second cycle, for example, the second 20,000 to 30,000 miles of its life, requiring that a more extensive job of reconditioning be done than was called for at the end of the first cycle. The company's experiences prompted it to establish what seemed to be appropriate tolerances in the various parts of the units and, because of the difficulties experienced by manufacturers in adapting their scheme of operation, the company was virtually compelled to select what it calls "specialty shops" to which the various units such as engines, transmissions, differentials, starters and generators, might be sent regardless of the make. Having operated on this plan for several years, it finds a distinct uniformity in its experience with the reconditioned units. It is the exception when one fails prematurely.

One needs to look about but a short time to find fairly numerous instances of operators maintaining a more or less elaborate research and design function. This practice is very likely to lead to the development of special requirements in the purchase of new equipment, said Mr. Bennett, and this, in turn, can, as a rule, lead only to difficulties of maintenance. Rather a fine line as to where the operators' investigations should stop and those of the truck manufacturers begin is to be recognized, but to try to identify this point, seems well worth while.

Mr. Geschelin remarked in concluding the discussion that, even though a service engineer may be saddled with several different makes of vehicle, this does not necessarily prove that universal tolerances cannot be specified. In fact, this is just where the code could be of greatest value. He referred to Mr. Winchester's comment about service tools, agreeing that probably they are too numerous but saying that service tools are necessary and that the fact that a service manager has difficulty in selecting the right tool is merely unfortunate. As to Mr. Coleman's mention of cylinder-wall thickness, he said that this problem is not so serious as it seems, because foundry men know much more about foundry work today than they did 10 to 15 years ago. In reply to Mr. Horine, he said that the form of the curve may or may not be parabolic but that, without doing more research work, he is not sure that one could prove exactly what the shape of the curve is. All that he intended to do was to illustrate what he meant by the various critical points The shape of the curve really is immaterial, he said, so long as the fact is recognized that the slope changes sharply beyond a certain point of flexure in the curve.

[12] M.S.A.E.—Manager, automotive department, Associated Oil Co., San Francisco.

Should Warn Against Carbon-Monoxide Hazard

THERE is no doubt that the concentration of carbon monoxide in most garages is sufficient to cause a considerable reduction in the efficiency of workmen and that it would pay the owners of these garages to give more attention to effective ventilation. In the absence of mechanical ventilation, a very short time is required for an engine to dangerously contaminate the air even in a large shop with the windows closed in cold weather, especially if the exhaust gases are not led outside. The conditions are extremely dangerous in the ordinary private one-car garage. The permissible carbon-monoxide concentration for short exposures is 1.5 parts in 10,000; a concentration of 15 parts in 10,000 has been known to cause death when breathed for 1 hr.; 50 to 100 parts will cause death in a few minutes.

The gas is colorless, odorless and tasteless. Several simple indications for detecting and measuring its concentration have been placed on the market, but probably the most useful is the pyrotanic-acid apparatus developed by the United States Bureau of Mines and fully described in the Bureau's Technical Paper No. 373. It is simple enough to use, so even the layman would have no difficulty in mastering the method. Many first-aid charts give directions for emergency treatment for carbon-monoxide poisoning, and it would be well if these were consulted more generally by garage workers.

No effort should be spared by those engaged in the automotive industry and informed of the dangers in seeing that their own shops, garages and vehicles are rendered as safe as possible. Also, our constant endeavor should be to warn people, by publicity and personally, of conditions which we recognize as dangerous.—Prof. S. H. Graf, director of engineering research, Oregon State College, in a paper presented at a meeting of the Oregon Section.

Engineering Lectures Free to Unemployed

PRESIDENT BUTLER, of Columbia University, recently authorized Dean J. W. Barker, of the School of Engineering at Columbia, in New York City, to admit to classes of the school any bona fide engineers who are registered with the Professional Engineers Unemployed Committee for employment and who are certified to the school by the Committee. These men may attend the lectures, up to capacity of the classrooms, without payment of any fees and without receiving university credit.

Upon reporting at the office of the dean, these men choose the lectures they desire to hear and are assigned to seats. Arrangements can be made to attend laboratory classes in which no material is used up, provided the laboratory is of the type in which an observer may benefit from attending and if he will not hinder work of the class.

About 125 men are attending the classes at this session and the plan seems to be working well. The engineers appreciate the opportunity afforded by the University to brush up on engineering subjects without expense while they are not profitably employed.

Prosperity Awaits Liberation of the Engineer

MR. ENGINEER, you have played the shrinking violet long enough. You have remade Western civilization and created at the same time certain malignant evils—actual, like technological unemployment; potential, like a smash-up due to overspecialization. You should shoulder the burden of mitigating these evils; which means directing the destinies of the new society that you have built. You are responsible for it; you are the only group in the community capable of understanding its complicated structure. Statesmen, philosophers, generals, poets, may lead self-supporting communities, but only engineers may lead a great, interlocked economic structure, with a score of exposed live arteries throbbing in every metropolitan area. —From *The Nemesis of American Business*, by Stuart Chase.

Production Engineering

Making Piston-Rings Tight[1]

Production Requirements and Test Methods for Limiting Oil-Pumping and Gas Leakage

ONE of the fundamental factors, and not the least important one, affecting the operation of a modern internal-combustion engine is the condition of the cylinders. The importance of accuracy in cylinder finish cannot be overstressed. To assure most successful operation, the allowable taper and irregularity of cylinder bores should not be more than to a fraction of a thousandth of an inch. This does not refer solely to accuracy of machining the cylinders; many engines are designed in such a way that an accurately machined cold cylinder becomes greatly distorted when heated to operating temperatures. This usually is due to non-uniform and non-symmetrical cylinder castings; valve pockets sometimes are connected to the cylinder barrels in the castings in such a way that the higher temperatures of the exhaust ports are carried into the cylinder wall, with the result that adjacent portions of the cylinder may be distorted from a true circle as much as several thousandths of an inch. Also head-stud anchor bosses are frequently improperly tied to the cylinder wall so that, when the head is drawn into position, depressions of more than 0.001 in. are forced into the cylinder contour.

When a motor-car is driven at a speed of 80 m.p.h., which is not rare today, the engine is turning at approximately 4000 r.p.m. or more. If the engine has a 5-in. stroke, the piston and piston-rings travel at an average rate of speed of 3333 ft. per min., or more than 38 m.p.h. During this time, each piston starts and stops 8000 times per minute, which means that it travels at tremendous speeds at mid-stroke. When the piston-rings pass at such great speeds over the irregular surface of a cylinder bore, they bounce and jump exactly as does any object that is drawn over an uneven surface.

Compression-Ring Function and Design

Another important factor affecting engine operation is the piston-rings; and their satisfactory operation, like that of the cylinders, is dependent entirely upon the correctness and accuracy of their construction. Since rings of different types are used to prevent compression leakage, or blow-by, and oil-pumping, the rings may be classified as compression rings and oil-control rings. As the entire responsibility of sealing the combustion chamber falls upon the former, these rings must form an absolute edge-seat against the edges of the ring grooves in the piston, and the face of the rings must remain at all times in firm contact with the cylinder wall.

Obviously, inaccuracies in the cylinder bore will tend to unseat or vibrate the rings when they are moving at tremendously high speed. Also, the slightest rocking of the piston in the cylinder turns the plane of the rings away from right angles to the cylinder wall and destroys the full contact of the face of the rings with the wall, thereby permitting the gas under high pressure to enter and pass between the faces of the ring and the cylinder.

The characteristic of the ring that is most important to effect the seal is the degree of uniformity of outward radial pressure of the ring against the cylinder wall at all points of its circumference. This property of the ring is, in the simple one-piece type, embodied in the ring itself by giving it the correct initial shape while it is in the free, or open, state.

Effectiveness of Oil-Control Ring

Lubricating oil can find its way from the crankcase past the piston-rings into the combustion chamber by only two possible paths. One is around the back of the ring, between the ring and the piston, and the other is directly between the face of the ring and the cylinder wall. Possibly a very small percentage finds its way to the combustion chamber by the former path, but extensive experiments have proved that most of the troublesome oil passes between the face of the ring and the cylinder wall. Although compression rings are provided to seal the space between the piston and the cylinder wall, they also very materially affect oil-pumping, and preventing oil-pumping is nearly impossible unless the compression rings embody the correct characteristics.

Probably more patent applications have been filed on oil-control rings than on any other part of the engine. This may indicate that the oil ring is the most important factor affecting oil control, which probably is true, for to change oil consumption as much as 1000 per cent by a change in the effectiveness of the oil-control ring is not impossible. Among the many types of such ring available, the industry has almost universally adopted some form in which the outer and inner surfaces are in communication through slots or holes through the ring. This type has not only proved to be the most effective, but its high efficiency continues over a longer period of operation than that of any other type known. In connection with such a ring continuing the open path in the ring through the back of the oil-ring groove is necessary to provide an uninterrupted passage through which surplus oil removed from the cylinder wall will be returned to the crankcase. If the channels or slots through these rings are of insufficient size or extent, the flow of the surplus or bypassed oil will be restricted and such oil will be forced to pass above the oil ring and probably will find its way into the combustion chamber. Therefore a continuous channel in the face of the ring, connecting all the slots, has been found to provide the most effective oil control.

Obviously, oil can pass the face of the ring only when the ring does not remain firmly seated against the cylinder wall. As in compression rings, failure of the oil ring so to remain is due to insufficient tension or stability within the ring itself and to incorrect shape of the ring. Many rings have so-called humps and depressions in their face, as is revealed when measurement is made by accurate gages. The poorest kind of performance may be had from a piston-ring which, when placed in a perfectly circular gage, shows that the face makes 100-per-cent contact with the inside surface of the gage.

Gage Detects Deficient Pressure

Mere contact with the cylinder wall throughout its circumference is not an indication that the ring exerts correct radial pressure at all points. Measurement of many rings has shown that, frequently for a distance of 1 in. or more on the circumference, the ring exerted virtually no pressure against the cylinder wall. In such a case, the tendency of the oil to pass the face of the ring lifts the ring from the cylinder wall at such low-pressure sections and oil passes the ring without difficulty. Both compression and oil-regulating rings are susceptible to such inherent defects.

Determination of the relationship of the ring shape and the uniformity of outward radial pressure has been made possible by a recently devised gage known as the roller gage. This consists of a solid steel ring having an accurately machined internal cylindrical surface, the diameter of which is greater than that of the ring to be tested by twice the diameter of the individual inserted rollers. The small rollers are loosely contained in a circular retainer that is attached to the gage ring. They are preferably 17 in number and located so that they form an insert between the interior surface of the gage and the exterior face of the piston-ring. The rollers are spaced on

[1] From a Pittsburgh Section paper presented by Ralph R. Teetor, M.S.A.E., first vice-president, in charge of engineering, Perfect Circle Co., Hagerstown, Ind.

22½-deg. centers, with the exception of the two rollers located adjacent to the joint on either side.

When the ring is inserted in this gage, a very practical measurement of the outward pressure of the ring against the rollers can be made by turning each roller between the thumb and finger. This gage provides the most practical measurement of radial pressure that is generally known at present.

Engine Tests Support Theory and Practice

Real proof of all the theory and practice herein stated rests on the performance of the piston-rings in engines under ordinary service conditions. Such tests have been made many times in piston-ring-testing laboratories. A standard test is conducted by connecting the admission side of an accurate gas-meter to the breather of an engine connected to a dynamometer. Other openings from the crankcase to the atmosphere are sealed, so that all of the gas leakage or blow-by past the pistons is forced to leave the crankcase by the connection to and through the gas-meter. Under such conditions, the meter records the total leakage in cubic feet for the duration of the test. Such a result, divided by the time covered by the test, gives the amount of blow-by per unit of time, which is a convenient measure of the performance of compression rings.

Effectiveness of the oil-control ring is also ascertained in the same test by accurately measuring the oil put into the crankcase at the beginning of the test, then measuring the oil drained from the crankcase at the completion of the test. The difference furnishes an exact record of the total quantity of oil consumed. A series of such tests, varying in engine speed, is conducted to determine the characteristic performance of the rings.

A very interesting observation of such a series of tests is the speed at which the piston-rings show a tendency to vibrate, or leave the cylinder wall. This speed usually is indicated by an abrupt increase in the rate of blow-by and of oil consumption. Observing a record in which the blow-by has doubled or trebled between two consecutive tests in which the speed was increased by only 200 r.p.m. is not uncommon. An equally great increase in oil consumption may or may not occur at the critical speed of the compression rings. Usually a tendency exists for the performance of the oil rings to break down, and the speed at which this occurs is indicated by the beginning of excessive oil consumption.

Critical Speeds Raised above Driving Range

The problem confronting the engine and the piston-ring engineers is that of raising these critical speeds above the driving range of the engine. In the design of many of the newer types of engine and the latest piston-rings, these critical or break-down periods have been raised to more than 4000 r.p.m., which is well above the speed at which engines turn under usual driving conditions. The importance of this lies in the fact that excessive blow-by and oil consumption are two of the greatest known contributors to destruction of the pistons, piston-rings and cylinders. The hot gases passing between the pistons, rings and cylinder walls burn the lubricating oil from the bearing surfaces, so that direct metallic contact of the surfaces and consequently rapid wear result.

Excessive oil consumption results in an excessive deposition of carbon, much of which finds its way down past the rings and becomes mixed with the lubricating oil. This carbon is contaminated with road dust that enters the combustion chamber, and the mixture forms an abrasive that accelerates wear.

The minuteness of the quantities of oil involved in so-called bad oil-pumping engines is difficult for one who is not constantly working with these problems to appreciate. In an eight-cylinder engine that consumes 1 gal. of oil per 100 miles at 3000 r.p.m., which corresponds to a car speed of 60 m.p.h. on the average, the quantity of oil consumed per cylinder per stroke is approximately 0.0001 cu. in. If this were spread evenly over the surface of a cylinder having a 3¼-in. bore and a 5-in. stroke, the thickness of the film would be approximately 1/500,000 in. The same engine, with a normal oil consumption of, say, 1 gal. per 1000 miles, would require for sufficient lubrication the deposition on the cylinder wall during each stroke of an oil film having a thickness of only 1/5,000,000 in.

Other Factors Affecting Oil-Pumping

Besides the major factors mentioned, many less important causes contribute to oil-pumping. A very serious offender is the misalignment of connecting-rods, which tends to cock the piston in the cylinder and carry the rings in a plane that is not at right angles to the center-line of the cylinder bore. This has a decided tendency to unseat the rings, and is a serious contributor to both blow-by and oil-pumping. Loose main and connecting-rod bearings discharge more than the normal quantity of oil to the cylinders. In many cases the quantity is greater than can be controlled by any normal combination of piston and rings.

All of the oil consumed in an engine is not always discharged into the combustion chambers. In many cases a considerable quantity is lost through either the front or rear main bearing or both. Oil lost at these points usually is discharged only when the engine is in operation, and many times only at the higher driving speeds. Such losses can be checked only by observations made when the engine is operating at considerable speed.

Apportioning Overhead

E. F. DuBRUL, general manager of the National Machine Tool Builders' Association, made some pertinent remarks on distribution of overhead in accounting at the Milwaukee Section Production Meeting. His remarks, which follow, were provoked by the omission of labor cost in a cost comparison given in one of the papers, the omission being explained by the complication which overhead would introduce.

Distributing overhead as a percentage of labor cost is one of the world's worst methods. How would this work out in a factory like the automatic frame plant of the A. O. Smith Corp.[1], where the parts are all handled automatically and there is virtually no direct labor? Still, some accountants and managers continue to figure the overhead in that way.

In the machine-tool industry, we believe that overhead should be analyzed into three parts, including: first, space occupied, with the light, heat, ventilation, and repairs, taxes, insurance, depreciation and interest on land and buildings; second, equipment, including interest, depreciation, taxes, repairs and power; and, third, the main element which includes supervision, supplies and indirect labor. Thus is built up an hourly rate which includes the above rates for the man, the machine and the space. A composite rate which is made up in this way means something. We know of no other good way to make an overhead rate that will allocate overhead proportionately.

Summer Industrial-Management Course

THIS year's summer course in industrial management at the Pennsylvania State College is to be held from June 8 to 16, inclusive, and will be under the auspices of the department of industrial engineering, with the cooperation of the engineering extension department. The faculty for the course consists of men well trained, not only in management theory, but also by reason of practical plant experience.

Topics for study this year include: industrial organization; principles, methods and applications of production control; trends in personnel management; principles of operation study; economic control of quantity and quality; standard costs; methods of industrial training; causes of budget failures; factory layout; and the development of executive ability.

This summer course, inaugurated in 1915 by Hugo Diemer, yearly attracts many executives and foremen who, having had plant experience, desire to progress further in their knowledge of plant management, through study of the principles of industrial management. College-trained executives also return to learn the most recent developments in the field of management.

As industry is now carefuly scrutinizing its methods of operation, it is believed that managements will see the wisdom of sending their most promising young executives to attend such a course, which awakens executives to new viewpoints of their jobs and leads them to make further studies.

[1] See S.A.E. JOURNAL for May, 1928, p. 565.

Aeronautic Meeting Highly Successful

(*Concluded from p.* 21)

Society will afford an opportunity to designers, manufacturers and air-transport operators to discuss their mutual engineering problems in the maintenance field.

Notables Gathered at Aviation Dinner

One of the greatest gatherings of aeronautic executives, engineers and famous pilots was seen at the Aviation Dinner, held jointly by the Society and the Aeronautical Chamber of Commerce on Thursday evening, at which the Detroit Section acted as host. Alex Taub, Chairman of the Section, formally opened this function with a short address of welcome, ending in his introduction of the toastmaster, William B. Stout. Under the guidance of the toastmaster, the events of the evening moved forward rapidly, commencing with the introduction of the following guests:

Ralph DuBois, Assistant Vice-Chairman for Aeronautics, Detroit Section
Ray Cooper, manager, National Aircraft Show
J. M. Schoonmaker, president, General Aviation Corp.
Charles S. ("Casey") Jones, vice-president, Curtiss-Wright Corp.
R. C. Marshall, president, Transamerican Airlines
Beeler Blevins
G. B. Grosvenor
J. A. Allard, president, Curtiss-Wright Flying Service
James H. Doolittle
Alex Taub, Chairman, Detroit Section
Clifford W. Henderson, manager, National Air Races
Vincent Bendix, Past-President of the Society and president of the Bendix Aviation Corp.
Clarence M. Young, Assistant Secretary of Commerce for Aeronautics
Charles L. Lawrance, President, Aeronautical Chamber of Commerce of America and Vice-President of the Society, representing aircraft-engine engineering
A. J. Scaife, President of the Society
Admiral William A. Moffett, U. S. N.
William B. Mayo, chief engineer, Ford Motor Co.
Ralph H. Upson
Harold F. Pitcairn, president, Pitcairn Aviation of Pennsylvania, Inc.
J. Griswold Webb, Chairman, New York State Aviation Commission
Stephen J. Zand
Luther K. Bell, General Manager, Aeronautical Chamber of Commerce of America
Harold S. Johnson
W. S. Pritchard, Vice-Chairman for Aeronautics, Detroit Section
Prof. Peter Altman, University of Detroit
L. B. Manning, Century Airlines

A stirring talk by Charles L. Lawrence opened the series of events that followed. The guest of honor and speaker of the evening, the Hon. Clarence M. Young, presented in his inimitable way the problems of the Government in its endeavor to assist the development of commercial aviation. His outstanding success in his work and the high regard in which he is held by every member of the aeronautic fraternity are indicated in the Nation-wide interest and comments that have been aroused by his address.

To Secretary Young and Vincent Bendix fell the joint duty of presenting the Bendix Trophies. The Bendix Trophy Race, a long-distance classic from the West Coast to Cleveland, was set up by Mr. Bendix in 1931 through the sponsoring of a large trophy known as the Bendix Trophy. Replicas and a considerable cash award are to be given annually to the winners of first, second and third places, respectively. To Major James H. Doolittle was awarded a gold replica of the large trophy as the winner of the first place in 1931, with silver and bronze replicas to Harold S. Johnson and Beeler Blevins, respective winners of second and third places.

To Stephen J. Zand was awarded the Wright Brothers' Medal for his paper on Airplane Vibration, presented at the Aeronautic Meeting of the Society in Cleveland in August, 1931. The presentation was made by Ralph H. Upson, a member of the Board of Award, in the absence of the Board's chairman, Capt. E. S. Land.

With the exception of "Bill" Stout, the chairmen of the various sessions were introduced by Detroit aeronautic men, who welcomed those in attendance on behalf of the Detroit Section, which cooperated in the conduct of the entire meeting. Through this cooperation, the splendid student meeting was held as the opening session; the Chairmen were introduced and the guests at the dinner were cared for by a Reception Committee, and all the details in connection with the tickets, entertainment and other matters involving the successful conduct of this banquet were handled by the Section.

Council Eases Reinstatement Requirements

MEMBERSHIP matters were the principal items discussed at a meeting of the Council, called by President Scaife, in Detroit on Tuesday, April 5, the day preceding the S.A.E. Aeronautic Meeting. Those present were President Scaife; Vice-Presidents Bachman, Neerken, Poole, Roos and Stout; Councilors Duesenberg, Shidle, White, Wilson and Woolson; Past-President Warner; Chairmen Taub of the Membership Committee, and Upham of the Lubricants Division; and Secretary Warner.

The Council took action that was favorable for former members of the Society who desire to be reinstated at present. This action provides that any former member who resigned in good standing can reinstate his membership in the Society up to the time of the close of the membership campaign simply by paying one-half year's current dues, no new initiation fee being required. In the case of former members who were dropped for delinquency, the Council directed that the membership of these men shall be reinstated in this same period upon their payment of one full year's dues, no new initiation fee or back dues being required.

Favorable progress in the Get-Your-Man campaign was reported, the Philadelphia Section having gained first place among the Sections by having the largest percentage of its quota of new applications. Sixty-five applications for membership, six grade transfers and four reinstatements were approved, and four applications were reapproved.

Progress was reported in connection with the coming Summer Meeting and the remaining meetings to be held during the calendar year, and the Council voted to hold the 1933 Transportation Meeting in Chicago during the time of the Century-of-Progress Exposition.

J. C. Hunsaker was appointed as the Society's representative on the Daniel Guggenheim Medal Board of Award for a term of four years, and Dr. G. W. Lewis was appointed as the Society's representative on the American Committee on the Marking of Obstructions to Air Navigation.

With sympathetic regret for the recent death of Past-President H. M. Leland, the Council passed a fitting resolution to be transmitted to his family.

News of the Sections

Brakes and Ford Engineering

Pittsburgh Section Considers Them with Relation to Maintenance and Service

THREE speakers, talking motion pictures and musical entertainment held the interest of 67 paid dinner guests and 117 members and guests of the Pittsburgh Section until 11:15 p. m. at the monthly meeting on April 5 at the Fort Pitt Hotel. The speakers were Dr. F. C. Stanley, chief engineer of the Raybestos division of Raybestos-Manhattan, Inc., whose subject was Brakes and Lining Problems; Frank L. Main, sales engineer of the Kelsey-Hayes Wheel Corp., who spoke on Brake Drums, Their Manufacture and Maintenance; and Murray Fahnestock, technical editor of the *Ford Dealer & Service Field*, who presented a paper on Some Fundamentals of Ford Engineering Design. The talking picture, called Live Wires, shown by W. A. Battle, of the Packard Electric Co., showed the production of ignition cables. Chairman B. H. Eaton presided.

Brake Questions and Answers

Dr. Stanley propounded a list of 24 questions on brake-maintenance problems and answered them seriatim. The answers covered the essentials of brake performance, the factors on which it depends and how it is measured; reasons for variation of brake performance in different localities; limitations of asbestos brake lining; relation of character and weight of the brake drum to lining performance; importance of silent brake operation; contribution of self-actuation to brake effectiveness; need of power brakes on trucks and motorcoaches; how design can assist in the problem of coach braking; relation of free-wheeling to brake maintenance; amount of power absorbed in braking; advantages and disadvantages of disc brakes; relation of low-pressure tires to the braking problem; and prevention of destruction of the braking surface of cast-iron drums used in trucks and motorcoaches.

Regarding brake-drum maintenance, Mr. Main said that, because of varying operating conditions in different localities, only general advice can be given in regard to brake service and maintenance. Such advice must be modified to suit conditions existing in a particular locality. He described in his paper the methods of manufacture of brake drums and how to maintain them in best condition.

Mr. Fahnestock, after defining an automobile as the mechanical embodiment of an idea by the combination of component parts which are primarily a means to an end, stated that for many years the battleship was one of the greatest combinations of engineering compromises ever known. Defining "compromise" in an engineering sense as a mixture of common sense with calculations, he said that the modern automobile is the most intelligent combination of wise engineering compromise ever effected.

Planning of the new Ford car was started by Henry Ford, according to Mr. Fahnestock, by making drawings of people and then engineering the car to fit the people. The policy of the company of making constant improvement in its cars, but no yearly models, which was adhered to for nearly quarter of a century, is being continued. Mr. Ford was credited by the speaker with introducing in 1908 the innovation of placing the driver's seat and controls on the left and pioneering the casting of four cylinders and the upper half of the engine crankcase in a single block, reducing the cost of the block below the price usually charged for a single cylinder. The new V-8 has two groups of four cylinders cast integrally with the upper half of the crankcase, and in the event of a damaged cylinder, the block can be replaced at reasonable cost. Another important contribution to ease of servicing made by the Ford Company, also in 1908, was the removable cylinder head. Troublesome experiences encountered in aligning the engine and the transmission were eliminated by combining them in a unit powerplant.

In explanation of why Ford had not brought out a six-cylinder car, Mr. Fahnestock pointed out that the eight-cylinder engine is as compact as the four and is interchangeable with it in the same chassis; also that of all the cars that finished among the first 10 in the Memorial Day races at Indianapolis since 1911, 70 had 4-cylinder engines, 10 had 6-cylinder engines, and all the rest, with the exception of one 12 and one 16, were 8-cylinder cars.

Transverse springs are retained because of reduction of unsprung weight and consequent easier riding. However, the Ford Company, besides two springs in the Ford passenger car, uses three springs in the truck, four in the Lincoln and five, including two helper springs, in the heavy-duty truck that has been developed recently.

Old Man River at Milwaukee

SEEMINGLY unrelated to automotive engineering, the subject of Mississippi River Flood Control, presented at the April 6 meeting of the Milwaukee Section, was shown to have a connection through some of the equipment used in the work. About 100 members and guests attended the meeting, which was held at the Milwaukee Athletic Club, of whom 42 were present at the dinner and entertainment preceding the technical session.

The main paper was presented by F. Carl Ruhloff, of the Bucyrus-Erie Co., and was supplemented by a short paper by C. E. Prudden, of the Allis-Chalmers Mfg. Co. Mr. Ruhloff gave many interesting facts and figures about the methods used by the Government engineers and the vast quantities of materials to be moved in the work of flood prevention. Mr. Prudden dealt specifically with the tractors and other automotive equipment in use in the work, such as elevating graders, crawler wagons and blade graders. Several hundred tractors of the largest commercial sizes are regularly engaged on the levee project, he said. The varied work of these and of the various dirt-moving machines hauled or driven by them was described and illustrated with lantern slides. Operations usually are carried on 24 hr. per day, the tractors averaging 20 to 22 hr. of work per day and up to 5000 hr. per year. Maintenance of the machines is conducted out of doors as a rule, although a canopy sometimes protects the mechanics against the hot sunshine, he said. Sledge-hammers and crowbars are the tools most used.

Airplane Problems Aired at Seattle

AERONAUTICS was discussed at the meeting of the Northwest Section held in Seattle on April 18. Philip G. Johnson, president of the Boeing Airplane Co. and United Air Lines, spoke on Engineering and Its Relation to Aviation, and C. N. Monteith, chief engineer of the same company, discussed The Development of Transport Airplanes. Both speakers covered a broad field and each brought out many points of interest. Section Chairman C. H. Bolin presided ably.

Secretary J. G. Holmstrom made a strong appeal for a better showing by the Section in the Get-Your-Man drive. Sherman Bushnell, Chairman of the Program Committee, announced that the final meeting of the year, in May, will be a marine meeting.

Stating that the heart of the aviation industry is the engineering department, Mr. Johnson said that costly research is being carried on by engineers and development is moving fast, new designs and new types continually being evolved. Individual buyers comprise the smallest part of the airplane market as a source of revenue, he said, and development of this field is far in the future. Commercial transport takes about one-third of the total production, with Army and Navy requirements providing by far the largest market.

Three years is about the life of both military and transport-type planes, obsolescence making them out of date.

Mr. Johnson pointed out that the five-year procurement program of the Government is at an end, leaving future Government requirements uncertain. He urged support by engineers of a new program that will mean continuation of airplane development in this Country. The air-mail deficit he figured at only around $6,000,000. Commercial equipment will not take care of military requirements in event of a war, he asserted.

What Designers Must Consider

When credited by Chairman Bolin with responsibility for the Boeing engineering advances, Mr. Monteith said that it never is right to say that any one engineer designed a certain airplane; "a group of 15 to 100 men can be justly credited with the designing of any new type; we have 80 men on the drafting board and all contribute."

In the design of a transport plane, said Mr. Monteith, the operator must first be considered; comfort is required; costs must be kept down so that depreciation will not be too great and performance, speed and climbing abilities are essential. A goal is to keep a plane in the air for 12 out of every 24 hr. A weight of 11 lb. per hp., including gross load, is a limiting factor with which the engineer must start. This presents a troublesome problem as regards comfort for passengers. Airplanes are now "built around the passenger", and whereas three years ago a plane of a certain size rated 15 places, the same plane is now rated 8 places, allowing more seat room. The heating problem has not yet been solved.

Next the radio man must be considered and then the pilot also must be satisfied. Visibility and stability are requirements to be met. Then come the aerodynamic considerations concerning wing-spread, tail surfaces and so forth. Last comes the structural engineer, who has to figure on a payload of about one-third of the gross weight, with the fuel and oil requiring about 10.8 per cent; crew of two men, 3 per cent; twin engine, in the type of plane under discussion, and propeller, 14 per cent; then also the starter, fuel tanks and the like, which leaves the designer control of only 37 per cent of the gross weight. Roughly, the payload represents about one-third, the powerplant weight one-third and the structure one-third.

The hope for the future is a lighter and stronger material. An aluminum alloy containing 4 per cent copper was recently adopted, said the speaker, thereby increasing the strength about 20 per cent. He predicted that commercial airplanes that will cruise easily at 200 m.p.h. using not more than three-quarters of their power, will be a reality within five years. Recently his company produced a fighting plane that flew 2200 miles in 12 hr. for its delivery.

Remarkable progress has been made in increasing the speed of transport planes. In 1918 the fastest fighting ship was 20 m.p.h. slower than the modern transport. Faster ships must have greater strength, because the effect of air bumps is more severe at the greater speed. Better material and improved designs will offset problems of greater speed, declared Mr. Monteith.

As to size, an economical limit exists, which trial and error will establish. He ventured the opinion that the ideal size for commercial transport planes is one that will accommodate 8 to 12 passengers and 2 pilots, with ability to fly for 5 to 6 hr. between landings. Forced landings because of weather conditions will not be avoided for a long time to come, in his opinion, and ships should be made so safe that parachutes for passengers will not be required. However, as air traffic becomes greater, especially near large aviation centers, rigid control or regulation is necessary to minimize danger of collisions.

Cleveland Considers Traffic Regulation and Headlighting

CLEVELAND Section's monthly meeting on April 11 was held at Nela Park, where, as guests of the General Electric Co., 125 members inspected the Lighting Institute exhibits of good lighting and fixtures for both factory and home. A dinner, accompanied by entertainment, was served to 75 members, and 50 more came later to hear two good addresses.

The first speaker was Col. Chalmers R. Wilson, Commissioner of Motor Vehicles for Ohio, and the second was W. C. Brown, illuminating engineer of the General Electric Co. Mr. Eason, of the Leece-Neville Co., described and demonstrated a 1200-watt voltage-controlled motorcoach generator under full load.

Colonel Wilson, in his talk, spoke of the great need for nation-wide adoption by the States of a uniform traffic code such as the Hoover Code and said that 14 States now have a central committee working on such a program. He gratified his audience by stating that present motor-vehicle license fees and the gasoline tax are too high; in 1931 the returns for licenses in Ohio were $13,000,000 and for the gasoline tax, $40,000,000. He advocated general reciprocity among the States in the matter of recognizing motorists' registrations and licenses, which promotes touring and trade, and said that Ohio is a leading State as regards reciprocity. He believes that drivers should be licensed in all States, that they should be trained in driving, that some form of financial responsibility should be required of vehicle owners, that the highways should be patrolled and that the commissioner of motor-vehicles should have authority to inspect vehicles and rule them off of the highways if the equipment is not in safe condition and the head-lamps are not good and in correct adjustment.

Head-Lamp Improvement Described

Mr. Brown illustrated his talk with light patterns thrown on the screen by sample head-lamps. He discussed headlighting briefly from the early days, touching on the work done by the S.A.E. Lighting Division and the Illuminating Engineering Society on what constitutes desirable road lighting. He pointed out the limitations of the old single-lamp fixed-beam head-lamp, which led to the development of the dual-beam devices now standard on virtually all cars and the improvements that have been made in the actual head-lamps themselves. The limitations of the present equipment are overcome to a large extent, he said, by what appears to be the next major step in the art—asymmetric-beam devices. The first of these to be adopted is now standard equipment on one make of car. With such equipment, driving on the open road is greatly facilitated. The asymmetric passing beam permits safe and comfortable passing because light is directed far ahead down the right-hand side of the road, past the on-coming car and is out of the eyes of the approaching driver.

Much can be said, remarked Mr. Brown, on what constitutes perhaps the most serious problem, that of proper use of the lighting equipment by the individual motor-vehicle operators. This brings in the work of some States in trying to enforce proper adjustment, although as yet little attention has been given to proper use. Dimming is very bad, tilting the beam being an improvement.

Missouri Highways and Transport

WHAT the State of Missouri is doing to provide an adequate highway system for motor transportation was told to 35 members and guests of the St. Louis Section at a meeting on March 31 in the Coronado Hotel. The speaker was J. A. Anderson, superintendent of equipment of the Missouri State Highway Department. His subject fitted in admirably with a talk given by President Scaife of the Society, who spoke on the engineering requirements to conform with highway-transportation regulation and taxation. General Manager John A. C. Warner addressed the members briefly on the activities of the Society.

Mr. Anderson told the gathering that, following approval by the voters of the State of a $60,000,000 bond issue for road construction, the Missouri Legislature passed a road law in 1921 designating a State road system of 7600 miles. In 1928 an additional bond issue of $75,000,000 was voted at a general election to speed up construction and the completion of the system. The present program, covering the period up to 1937, contemplates construction of the original 7600 miles, an additional 300 miles, about 96 miles of park connections, approximately 318 miles of traffic-relief roads and the construction of 7000 miles of supplementary roads.

The State's transportation problem was stated by Mr. Anderson in simple terms as "that of building roads to fit the traffic," which always has been the desire of motor-vehicle users but is a complex problem because of the ever-changing and expanding traffic. The speaker next spoke of the numerous bills introduced in last winter's sessions of the various State legislatures to regulate motor-truck and motor-coach traffic and of the investigation made by the Highway Transport Committee of the American Association of State Highway Officials on the effects upon the highways and bridges of various types of motor-vehicle and of

overloads. In conclusion, he said that he is sure that a just distribution of freight between the railroads and the truck-transportation lines will be worked out and that the products of farm and factory will be transported in the most practical, efficient and economical ways.

Future Trucks and Buses Debated at Metropolitan Meeting

PROBABLE design and characteristics of the motor-trucks and motorcoaches of the future were indicated by three speakers at the meeting of the Metropolitan Section on April 22. The speakers were B. B. Bachman, of the Autocar Co.; Col. E. S. Stayer, commanding officer at the Holabird Quartermaster Depot; and Pierre Schon, of the General Motors Truck Co. The meeting was held in the A. W. A. Clubhouse in New York City, where 130 members and guests enjoyed the members' dinner and accompanying organ music and 165 attended the technical session that followed.

Mr. Bachman stated his belief that the Diesel engine will not be the prime mover in motor-trucks and motorcoaches, that the powerplant may be confined to rotary motion and that none of the present types of clutch and transmission will prove final. A heavier grade of gasoline than is used at present will be the fuel employed. Wheels may be independently sprung and the chassis will have no frame. Operation of the vehicles will be simplified so that they will be controlled merely by steering and by two levers, one for starting and regulating the speed and the other operating the brakes.

Colonel Stayer spoke of the work of the Quartermaster Corps in developing specifications for five groups or classes of truck ranging from 1½ to 7½-ton capacity, with the object of standardizing the units to simplify maintenance and repair work. His paper covered much of the information given in the paper entitled, Powerplants and Their Relation to the Military Motor Transport of the Army, which he presented at the Annual Meeting last January.

Mr. Schon spoke of the restrictions on truck and motorcoach design imposed by State limitation of size and weight, and also the economic effect of exorbitant taxation in the guise of registration fees.

Marine Section Organized

At a recent organization meeting of the new Marine Section, which is represented by William E. John, of the Sterling Engine Co., as Vice-Chairman of the Metropolitan Section, plans were formulated for monthly motorboat meetings, starting next October. The organization meeting was attended by A. E. Luders, chairman of the Technical Committee of the National Association of Engine & Boat Manufacturers; George H. Townsend, President of the American Power Boat Association; and John A. C. Warner, General Manager of the Society.

The May meeting of the Metropolitan Section is to be a Motorboat Meeting at which navigation, safe motorboat practices and equipment will be discussed.

Syracusans Hear about Lighting

AUTOMOBILE Headlighting for 1932 was the subject on which 42 members and guests of the Syracuse Section were addressed by W. C. Brown, illuminating engineer of the General Electric Co., at the meeting of the Section on April 14 at the Syracuse Hotel. A dinner for the speaker and Section officers was held before the technical session.

Following delivery of the paper, the subject was discussed mainly by C. W. Frederick, of the Brown-Lipe-Chapin Co.; C. P. Grimes, of the Grimes Brake Engineering Service, and Matthew S. Watson, superintendent of maintenance of the Eastern Greyhound Lines, Inc.

Dayton Aviation Meeting

WITH an attendance of 250, Dayton Section's meeting at the Engineers Club on April 19 was addressed by J. S. McDonnall, of the Great Lakes Aircraft Corp., on the relation of engineering to aviation; and by Capt. A. F. Hegenberger, of Wright Field, on new navigation instruments. Various instruments were explained and demonstrated.

Canadians Interested in Antiknock

WITH an attendance of more than 100, including a large turn-out of oil men, the April meeting of the Canadian Section, held at the Royal York Hotel, Toronto, on the 20th, was addressed by Homer E. Dedo, research engineer of the Ethyl Gasoline Corp. George W. Garner, Chairman of the Section, presided.

Mr. Dedo outlined the various ways in which the efficiency of the internal-combustion engine has been increased, illustrating these with lantern slides, and discussed "knocking" in engines. The speaker demonstrated with a special engine the effect of different antiknock substances.

Alloys Used in Automobiles

SPECIAL Metals Used in Automobile Construction was the title of a paper presented by E. B. Neil at the April 13 meeting of the Philadelphia Section. When the speaker finished, the subject was discussed by W. J. Diederichs, metallurgist of the Autocar Co.; William J. Mayer, assistant to the chief engineer of the Edward G. Budd Mfg. Co., and others.

As usual, the meeting was held at the Section headquarters in the Philadelphia Automobile Trades Association Building and was preceded by a members' dinner, at which a surprise entertainment was provided under direction of O. M. Thornton.

Kansans Entertain Society Officers

PRESIDENT A. J. SCAIFE and General Manager John A. C. Warner, of the Society, were guests of honor of the Kansas City Section at its dinner meeting on March 29, at which the attendance was 37.

Mr. Scaife addressed the gathering on the subject of Highway Transportation, and Mr. Warner spoke about activities of the Society.

Others who made short talks pertinent to the subjects were Robert Collins, R. H. Van Ness, C. L. Brosseau and Harry Rasmussen.

Chicago Section Holds an Engine Session

ENGINE design and power ability were discussed in two papers presented at the April 5 meeting of the Chicago Section, held as usual at the Hotel Sherman, where 69 attended the members' dinner and 138 were present at the technical session.

James B. Fisher, chief engineer of the Waukesha Motor Co., the first speaker, presented a paper entitled, Some Factors Controlling Engine Design. The second paper, under the query title, How Much Power Can an Automobile Engine Produce?, was prepared by Earl Bartholomew and Homer E. Dedo, of the Ethyl Gasoline Corp., and, owing to the illness of Mr. Bartholomew, was presented by Mr. Dedo. Prepared discussion was given by John Erskine, research engineer of the International Harvester Co.

H. W. Zimmerman, of the Automotive Maintenance Machine Co., made a brief statement regarding membership in the Society.

In the Bartholomew-Dedo paper, the authors discussed the methods and limitations of increasing power output by increasing the cylinder dimensions, the number of cylinders, the speed and the inlet-manifold pressures (by supercharging) and by improving the engine efficiency. The major part of the paper was devoted to the last means and the relation to it of the fuel question. The effects of increased compression ratio on the engine elements was considered in detail and illustrated with charts and diagrams. In conclusion, the authors mentioned changes in the oil industry to supply fuels of high antiknock value and the cooperation of the automotive and the oil industries in the solution of their mutual problems.

Engine Designing Needs Leadership

In his extensive paper, Mr. Fisher showed by curves how demands made of engines resulted in power increases from 58 hp. and a maximum brake mean effective pressure of 87 lb. per sq. in. at 1500 r.p.m. for a four-cylinder engine of 500 cu. in. displacement in 1912 to 152 hp. and a brake mean effective pressure of 110 lb. per sq. in. at 2700 r.p.m. for a six-cylinder engine of the same piston displacement at present, all figures being based on a compression ratio of 5:1 and a gasoline of not higher than 60 octane number. Much emphasis was placed by the speaker upon the importance of improved materials to the improvements in engines made in the last 20 years.

Well-defined limitations within which the designer must work were reviewed and air-cycle, mechanical, combustion and volumetric efficiencies were discussed as factors limiting the amount of

(*Continued on p. 40*)

Henry Martyn Leland

INTERCHANGEABLE manufacture, previously practised only in making smaller products such as firearms, was introduced into the automobile industry by Henry M. Leland, who died March 26, after an illness of several weeks, at Grace Hospital, Detroit, at the age of 89 years. Mr. Leland was President of the Society in 1914 and was a supporter of its standardization work, which was then beginning its period of greatest activity. His membership dates back to 1909.

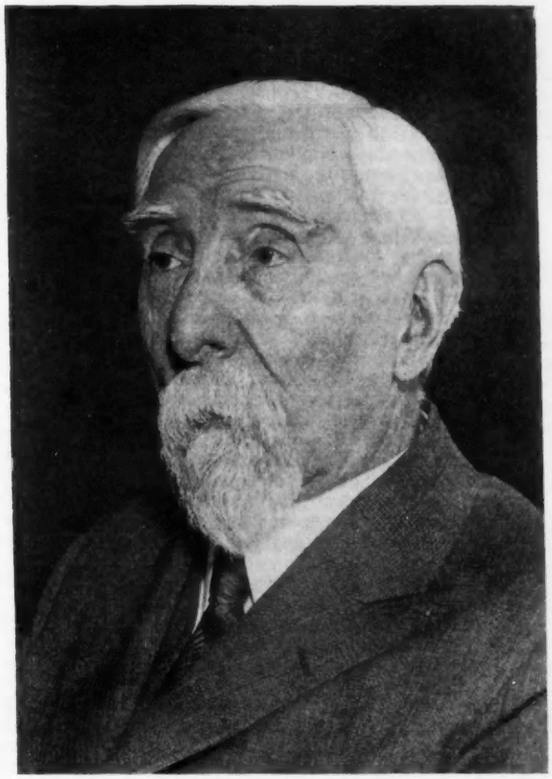
Born at Danville, Vt., Feb. 16, 1843, Mr. Leland was a toolmaker in the United States Arsenal in Springfield, Mass., throughout the Civil War. During the next 20 years he was employed by the Brown & Sharpe Mfg. Co., of Providence, R. I., becoming superintendent of its sewing-machine department. While there he developed the first barbers' hair-clippers from the horse clippers that were manufactured by the company. Within a year, sales of the new clippers are said to have netted his employers a profit of $1,000 per day.

In 1890, Mr. Leland moved to Detroit, where he engaged in the manufacture of small tools under the name of the Leland & Falconer Machine Co. He brought with him the mechanical practices and standards of some of the best machine-shops of New England and soon became a gear expert. He manufactured the planetary transmissions of the early Oldsmobile curved-dash runabouts; he also made marine gasoline engines and engines for some of the experimental cars during the last decade of the 19th century.

A single-cylinder engine and an improved planetary transmission were developed at the Leland & Falconer plant for the first Cadillac car, and that name became famous largely because of the Leland & Falconer workmanship on the mechanical parts of the car. After a few years, the Leland and Cadillac companies were merged and Mr. Leland became president, a position which he retained until 1917, when he, with his son Wilfred C. Leland, withdrew to form the Lincoln Motor Co. and build Liberty aeronautic engines for the Government during the World War.

At first, the Lelands bought a plant with their own funds and equipped it to build about 20 engines per day, the number which had been suggested by General Squier, chief signal officer of the United States Army. When contracts were let, the number required of the Lincoln Company was 100 per day. Ground for a new $8,000,000 plant was broken Sept. 21, 1917, the roof was completed by Christmas Day, $2,000,000 worth of machinery was installed by Lincoln's Birthday, and the plant was dedicated on Washington's Birthday, 1918. By Aug. 31, one year after the contract was signed, the Lincoln company had delivered 2000 twelve-cylinder Liberty engines. It is said that the company established a record for the largest number produced in a single day, in a single month and in the year, although other manufacturers had a start of five months while the new Lincoln plant was being built.

When the Liberty-engine contracts were cancelled at the time of the Armistice, the Lincoln car was developed and put on the market. Receivership of the company was caused by the general deflation of 1920 and precipitated by a Government tax of $4,500,000 which interfered with negotiating a loan, although the assessment was later withdrawn.



HENRY MARTYN LELAND

In the days of the "one-lunger" Mr. Leland astonished the mechanical world with a demonstration of interchangeability that won for the Cadillac car the Dewar trophy, which was awarded annually in England for the most meritorious demonstration of the advancement of the automobile industry. Three cars were chosen at random from the warehouse of the Cadillac agency in London, the cars were taken to Brooklands track and completely dismantled and the parts were placed in one conglomerate heap. Duplicates from the stock of spares were substituted for 69 parts in the pile; then three complete sets of parts were taken from the main heap without regard to the cars from which they were originally taken, and three "new" cars were assembled. The only tools allowed were wrenches and screw-drivers; no files or emery cloth. After being assembled, all of the cars were started with a few turns of the crank and were driven several hundred miles on the track.

The Cadillac car received a similar award later for the introduction of electric starting and lighting, thus becoming the only car ever to receive the trophy twice. The two-speed axle, the V-eight engine and thermostatic control of engine temperature were other departures introduced on Cadillac cars under Mr. Leland's management.

Selection of the name of the company which he organized at the age of 73 was no whim, as Mr. Leland was an ardent admirer of the Civil War President, had a notable collection of Lincoln literature, and Mr. Lincoln's portrait hung on the wall of his office.

Mr. Leland carried with him the austere New England standards of honesty and conduct. He was associated with many social, benevolent and civic organizations, among them the Detroit Citizens League, of which he was a founder and for many years president. He was proud of having manufactured both rifles for the Civil War and airplane engines for the World War.

Arthur J. Slade

ONE of the earliest members of the Society, Arthur Jarvis Slade, formerly of New York City, is reported in news dispatches to have passed away in Naples, Italy, on March 30, as the result of a heart attack. He retired in 1924 and had made his home in Paris for the last eight years.

Mr. Slade is well remembered in automotive circles as a consulting motor-transport engineer in New York City from 1904 to 1924 and, after entry of the United States into the World War, as a captain and motor-transport engineer in the aviation section of the Signal Corps and later as a lieutenant-colonel in charge of the engineering division of the Motor Transport Corps with the American Expeditionary Force in Europe. For his war services he was decorated with the British Distinguished Service Order and the French Legion of Honor, and because of his expert knowledge of motor transportation was appointed a member of the Armistice Commission.

Born in New York City in 1872, Mr. Slade was graduated in mechanical engineering by Yale University in 1892

and was a special student in electrical engineering at the Columbia School of Mines in 1894. For four years thereafter he served in the office of George Hill, consulting engineer, in New York City, then entered the railroad field, first as superintendent of construction and equipment for the Central Railroad of New Jersey, at Elizabeth, N. J., then as assistant engineer and later mechanical engineer for the New York Central Railroad. Entering private practice in 1904 as a consulting engineer specializing in the design, construction and operation of commercial motor-vehicles, he devoted his attention to this field for the following 20 years. During 1913 he was chief engineer of the Atlantic Vehicle Co., of New York City.

Mr. Slade was elected a Member of the Society in 1907, his application carrying the serial number 78. He joined the New York Section, now the Metropolitan, upon its formation and served it as Treasurer in 1913. He was also a member of the American Society of Mechanical Engineers and of the American Institute of Electrical Engineers.

Hugh Reginald Corse

A SUDDEN heart attack resulted in the lamented death of Hugh R. Corse, sales manager of the Lumen Bearing Co., at his home in Buffalo on Feb. 20. Up to that time he was apparently in good health.

Mr. Corse was widely known in the engineering profession, particularly among automotive engineers, as he circulated widely in his activities as sales manager of the Lumen company and was Chairman of the Society's Sections Committee in 1921 and 1922 and an active member of the Non-Ferrous Metals Division of the Society's Standards Committee from 1926 to 1932. His contact with the research laboratory of the Lumen company for many years, with the Titanium Bronze Co. and with many engineers materially helped to develop correct alloys for specific purposes and to find new uses for non-ferrous metals and improved alloys.

Born at Malden, Mass., in February, 1880, Mr. Corse entered the automobile industry in its pioneer days, gaining shop experience with the Cadillac Motor Car Co., of Detroit, in 1903 and becoming foreman of the frame, axle and spring departments the following year. He built gas engines for Leland & Faulkner in 1903. From 1905 to 1910 he was engaged in selling magnetos, radiators, springs and other automobile parts in Detroit for the Hibbard Engineering Co. He also was employed in the Detroit shops of the Chicago Pneumatic Tool Co. and served for a time as purchasing agent of the American Blower Co. in Detroit. Joining the Lumen Bearing Co., of Buffalo, in 1910 as a salesman, he remained with the company for four years and then for six years was sales manager of the Titanium Bronze Co., of Niagara Falls, N. Y., afterward returning to the Lumen company.

Besides being an Associate Member of the S.A.E. since 1911, Mr. Corse was a charter member of the Detroit Athletic Club and a member of the Buffalo Engineering Society and other technical bodies.

Hugh P. Tiemann

WORD was recently received of the sudden death of Hugh P. Tiemann, assistant metallurgical engineer of the Carnegie Steel Co., of Pittsburgh, for the last 30 years and a Member of the Society since November, 1917.

Mr. Tiemann was born in New York City, in 1879, and was graduated by Columbia University with the degree of bachelor of science in industrial chemistry in 1900 and master of arts in metallurgy in 1901. Besides his membership in the S.A.E., he held active membership in the American Institute of Mining and Metallurgical Engineers, the American Society for Testing Materials, the Iron and Steel Institute (England) and the American Iron and Steel Institute. He served as chairman of the A.S.T.M. Subcommittee on Specifications for Steel Forgings and was a member of other technical committees of that society. He has presented a number of papers on metallurgical subjects before engineering societies and technology clubs.

Mr. Tiemann's only vocational connection has been with the Carnegie Steel Co., first as assistant metallurgist at the Homestead Steel Works; then after four years he took a course of training in the order and sales department, next he was made metallurgist in general and in 1915 he was appointed assistant metallurgical engineer.

Richard L. Gillespie

INFORMATION has been received that Richard L. Gillespie, technical sales representative of the Firestone Tire & Rubber Co., of Akron, Ohio, and an Associate Member of the Society since November, 1927, passed away recently.

Mr. Gillespie was born in 1898 at New York City, where he attended the public grammar and high schools. At 18 years of age he began work for the Firestone company as a factory hand. In 1922 he was assigned to technical work on the development of tires, and four years later was transferred to technical sales work, which work he continued up to this year.

F. J. Lane

THE sudden death of F. J. Lane, Detroit representative of the Alemite Corp., on Feb. 21 from an unknown cause has been reported to the Society.

Mr. Lane was elected an Associate Member in 1923. He was born at Grand Rapids, Mich., in 1890 and, after working for the Michigan Railway Co., at Jackson, Mich., for three years as stock-keeper, entered the automotive industry in the purchasing department of the Nordyke & Marmon Co. A year and a half later he joined Dodge Bros. as purchaser and remained for five years. He then was appointed sales manager of the General Wire & Spring Co. and thereafter was successively sales manager for the Allyne-Zerk Co., of Detroit, of which he became vice-president and general sales manager; vice-president and general sales manager of the Bassick Mfg. Co., also of Detroit, in 1927; and, in 1928, sales representative in Detroit of the Alemite Mfg. Co. He had been a member of the Detroit Section ever since joining the Society.

John M. Arnoldy

INFORMATION has been received from the Magneto Sales & Service Co., of Los Angeles, that its vice-president and manager, John M. Arnoldy, passed away on March 10.

Mr. Arnoldy, who became an Associate Member of the Society in March, 1927, was born at Minneapolis in 1878 and entered the automotive industry in 1918 as a salesman for the National Spark Plug Co., of Rockford, Ill. The following year he was appointed sales manager of the Pacific Coast division of the Fyrac Mfg. Co., of Rockford, successor of the former company. After three years in this position, he began selling the products of the Robert Bosch Magneto Co. for Furrer, Langner & Kinnear, of San Francisco. With the taking over of distribution of the Bosch products by the Magneto Sales & Service Co. in 1923, he continued selling them to corporations and appointing official service stations on the Coast; and in 1926 was elected vice-president and manager of the company.

Personal Notes of the Members

Reeves To Be Show Manager

Announcement was made last month that the board of directors of the National Automobile Chamber of Commerce had accepted the resignation of S. A. Miles as manager of the National Automobile Shows and that future shows would be under the management of Alfred Reeves, vice-president and general manager of the Chamber. Mr. Miles decided to retire after 32 consecutive years of management of the shows, the success of which was unparalleled in trade-show history, and his resignation was accepted with great regret. As heretofore, the future shows will be under the supervision of the Chamber's show committee, of which Albert R. Erskine, also a member of the Society, is a member.

Noville Engaged by Fuel Oil Motors Corp.

Announcement was made recently that George O. Noville had been engaged by the Fuel Oil Motors Corp., of New York City, as chief consulting engineer in the aeronautic field.

Following his graduation in 1906 by the Central High School in Cleveland, his native city, Mr. Noville spent 16 years in the United States Navy and during part of that time attended Columbia University and the Massachusetts Institute of Technology as a special engineering student. After four years as an engineering apprentice in the Navy, he entered the electrical division, and in 1914 was appointed chief electrician in charge of automotive equipment. Three years later, during the World War, he was appointed chief engineer and executive of the United States Naval Air Station at Porto Corsini, Italy. In 1920 he was superintendent of the United States Air Mail, in charge of all operations, maintenance and repairs. The following year he was placed in charge of inspection and acceptance of aircraft engines for the Army and the Navy, and in 1922, commissioned as a lieutenant-commander, he served as chief engineer at the Navy base at San Diego, Calif., in charge of maintenance of all aircraft-equipment shops and engineering personnel. He was selected in 1923 as one of the engineers to precede the Army Air Service round-the-world flight on the Greenland-Labrador leg.

Mr. Noville entered civilian service in 1922 as an automotive and aeronautic engineer with the Vacuum Oil Co., of New York City, and four years later transferred his connection to the Standard Oil Co. of California, in San Francisco, engaged in lecture work on aeronautic and lubrication engineering. In 1929 he was appointed general manager of Hawaiian Airways, Ltd., with headquarters in San Francisco, but last year was transferred to the New York office of that company. He was selected to accompany Commander (now Rear Admiral) Richard E. Byrd on his North Pole expedition in 1926, as aide and flight engineer; and was again chosen by Commander Byrd the following year in the same capacity in the preparation, testing, acceptance and flight of the America from New York City to Paris.

Mr. Noville was elected to Member grade in the Society in 1927 and presented a paper on aircraft-engine lubrication at an Aeronautic Meeting of the Northern California Section in San Francisco.

Protest Discriminatory Taxation

Alfred P. Sloan, Jr., Walter P. Chrysler, Edsel Ford, Roy D. Chapin and Harvey S. Firestone, members of the Society, were among a delegation of automobile and tire manufacturers who presented arguments against proposed sales taxes on automobiles, trucks, parts and accessories at a hearing before the Senate Finance Committee in the City of Washington on April 18. Chief spokesman for the industry was George M. Graham. The speakers expressed willingness of the vehicle and parts manufacturers to bear a sales tax that is imposed upon products in general, with the exception of food and clothing, but objected strenuously to the picking out of the automotive industry with a few others for special taxation. They pointed out the decrease in motor-vehicle production in the last two years, the great improvements in cars and the reduction in prices this year and the importance of revival of the industry to increased employment in many lines of manufacture.

Members Elected by Borg-Warner

Howard E. Blood, president of the Norge Corp. and the Detroit Gear & Machine Co., of Detroit, was elected first vice-president of the Borg-Warner Corp., of Chicago, parent company of the two organizations, following the recent annual meeting of stockholders of the Borg-Warner Corp. Other members of the Society who were reelected were G. W. Borg, chairman of the board of directors; E. S. Ekstrom, president of the Mechanics Universal Joint Co., vice-president of the Borg-Warner Corp.; and, directors, H. E. Blood, president of the Borg & Beck Co.; E. S. Ekstrom; D. D. Francis, president of the Wheeler-Schebler Carburetor Co.; and F. L. Morse, president of the Morse Chain Co.

Collier Trophy Presented to Packard

Alvan Macauley, as representative of the Packard Motor Car Co., was presented by President Hoover with the great bronze Collier Trophy at a gathering of aviation leaders in the City of Washington on March 31. The trophy was awarded to the company by the National Aeronautical Association for the year 1931 for its development of the Diesel aircraft engine, which President Hoover referred to as a "notable mechanical achievement and a contribution not only to economy but to safety in aviation."

The presentation was made on a side porch of the White ouse, where a full-size engine with propeller attached was shown to the President. Harold F. Pitcairn, who received the trophy last year for development of the Autogiro, a full-size model of which he flew to the White House grounds on that occasion, was among the group at this year's presentation, as were also F. Trubee Davison, Assistant Secretary of War for Aviation; Clarence M. Young, Assistant Secretary of Commerce for Aviation; Amelia Earhart Putnam and Glenn L. Martin.

Arthur F. Bassett has relinquished his position as managing director of the General Motors Export Co., of New York City. From 1926 to 1929 he was managing director of General Motors of Brazil, at Sao Paulo, and was then transferred to the New York City headquarters.

E. P. Blanchard, who was formerly head of the Production Activity of the Society, was elected to the board of directors of the Bullard Co., of Bridgeport, Conn., at the last annual meeting of the stockholders. He has been connected with the company for 12 years, having been advertising manager, assistant sales manager and assistant to the president before he became sales manager.

G. W. Carlson has been appointed chief engineer of the axle division of the Eaton Mfg. Co., of Cleveland. The company was formerly the Eaton Axle & Spring Co., and Mr. Carlson was director of engineering. He is a member of the Axle and Wheels Division of the Standards Committee of the Society.

At the recent annual meeting of stockholders of the Ross Gear & Tool Co., of Lafayette, Ind., **Eugene Grunewald,** formerly vice-president, was elected vice-president and general manager of the company, and **F. F. Chandler,** formerly vice-president, was elected vice-president and sales manager.

Kent S. Hardy, formerly district parts and service manager in San Francisco for the Cadillac Motor Car Co., is now service manager for Johnson Garages, Inc., of Monterey, Calif.

F. O. Paul is now in charge of sales in the New England States for the Ex-Cell-O Aircraft & Tool Corp., of Detroit. His headquarters are at Waltham, Mass. For the last two years he was connected with companies furnishing all types of tungsten-carbide tools.

Applicants Qualified

The following applicants have qualified for admission to the Society between Feb. 10 and April 9, 1932. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

ALLEN, FRANK C. (A) shop superintendent, International Harvester Co., *Portland, Ore.;* (mail) 824 East Taylor Street.

BARKER, GEORGE A. (A) draftsman, Forest Service, Department of Agriculture, *City of Washington;* (mail) 610 East Capitol Street, N. E.

BEECH, WALTER H. (M) president, Curtiss Wright Airplane Co., Robertson, Mo.; (mail) 110 North Elizabeth Street, *Ferguson, Mo.*

BRETTELL, CLINTON (M) superintendent of garages, R. H. Macy & Co., Inc., New York City; (mail) 87 Kingsbury Road, *New Rochelle, N. Y.*

BROUCK, R. H. (A) special fleet representative, E. I. duPont de Nemours, Inc., Detroit; (mail) 563 North Menard Street, *Chicago.*

BURNEY, SIR CHARLES DENNISTOUN (F M) chairman, Streamline Cars, Ltd., *London, England;* (mail) 20 Carlton House Terrace.

BUSSY, ROGER M. (F M) automotive engineer, Anglo-Persian Oil Co., *Abadan, South Persia.*

CARP, PETER, (F M) chief engineer, J. A. R., *Brasou, Roumania.*

CASE, RICHARD Y. (J) chief draftsman, L. H. Gilmer Co., *Tacony, Philadelphia;* (mail) 7334 Torresdale Avenue.

DAY, RAY E. (M) president, Ray Day Piston Corp. of Detroit, 6656 Walton Avenue, *Detroit.*

DICKSON, JOHN M. (M) section engineer, Westinghouse Electric & Mfg. Co., Philadelphia; (mail) 402 Cornell Avenue, *Swarthmore, Pa.*

ELDRIDGE, LEONARD C. (M) assistant manager, lubricating oil sales division, Shell Petroleum Corp., Shell Building, *St. Louis.*

FORD, STUART M. (A) vice-president and general manager, Collins & Aikman of Canada, Ltd., *Farnham, Que., Canada.*

FROHLIN, CHARLES ROBERT (J) mechanical engineer, chassis dynamometer, The Texas Co., Beacon, N. Y.; (mail) Box 351, *Fishkill, N. Y.*

GUILBAUD, THEODULE, ING. (F M) manager, Societa Anonima Carburetore Zenith, *Torino, Italy;* (mail) 9 Via Freidour.

GURTON, WILLIAM S. (A) vice-president and managing director, Dominion Truck Equipment Co., Ltd., South Street, *Kitchener, Ont., Canada.*

HAIGH, VAUGHN (M) executive engineer, Warner Gear Co., *Muncie, Ind.*

HAWKEY, LESTER F. (A) salesman, Edison Storage Battery Co., Orange, N. J.; (mail) 1745 Houston Avenue, *Kansas City, Mo.*

HAWLEY, CHARLES D. (M) assistant director, engineering laboratory, Ethyl Gasoline Corp., 723 East Milwaukee Avenue, *Detriot.*

HOWARD, JOHN R., 3RD (J) student, 396 Harvard Street, *Cambridge, Mass.*

HOWARD, NELSON, 2ND (A) 65 Robin Street, *West Roxbury, Mass.*

JEFFERSON, THEODORE BREWSTER (J) operations manager, Missouri Valley Aeronautic Club, *Kansas City, Mo.;* (mail) 12 West 58th Street Terrace.

JORGENSEN, N. A. (A) manager, Chicago branch, Wood Hydraulic Hoist & Body Co., Detroit; (mail) 301 West 37th Street, *Chicago.*

KEELING, HAL R. (A) vice-president, Sidener, Van Riper & Keeling, Inc., 901 Circle Tower, *Indianapolis.*

KLEISINGER, EMIL, DR. (F M) general manager, Richard Weber & Co., *Berlin, Germany;* (mail) Kottbuserufer 41, Berlin, S. O.

KNABLE, G. ELKINS (M) metallurgist, Carnegie Steel Co., Carnegie Building, *Pittsburgh.*

KOHLSTRAND, EDWARD A. (J) body engineering, minor layout, Hudson Motor Car Co., *Detroit;* (mail) 5562 Montclair Avenue.

KYLE, W. A. (A) salesman, Valspar Corp., Ltd., Walkerville, Ont., Canada; (mail) 152 Dowling Avenue, *Toronto, Ont, Canada.*

LETIMER, GEORGE T. (A) manager, industrial division, S. S. White Dental Mfg. Co., 152 West 42nd Street, *New York City.*

MARBACH, E. R. (A) secretary, engineer, Whiteway Stamping Co., *Cleveland;* (mail) 1201 East 55th Street.

MCGINTY, HUGH JAMES (J) truck and fleet division, Ford Motor Co. of Canada, Ltd., East Windsor, Ont., Canada; (mail) Apartment 108, Parkside Apartments, 400 Giles Boulevard, West, *Windsor, Ont., Canada.*

MCNERNEY, JOHN J. (A) vice-president, Hy Vis Oil Refining Co. of California, 424 Commercial Street, *Los Angeles.*

MEGARGEE, STANLEIGH (M) supervisor of automotive equipment, Pie Bakeries, Inc., 1060 Broad Street, *Newark, N. J.*

NEEDLES, I. G. (A) sales manager, tire division, Canadian Goodrich Co., Ltd., *Kitchener, Ont., Canada.*

PEARSON, C. F. (M) designer, special machinery, Curtiss Candy Co., *Chicago;* (mail) 3906 North Sawyer Avenue

PRILL, PAUL E. (M) chief engineer and superintendent, Stolper Steel Products Corp., 3300 Fond du Lac Avenue, *Milwaukee.*

RECTOR, CLINTON (A) engineer, Bakelite Corp., 247 Park Avenue, *New York City.*

ROCHFORD, ALAN V. (J) body engineer, general manager, T. Rochford Sons, Inc., 1066 Bedford Avenue, *Brooklyn, N. Y.*

SHIELDS, FRANK D. (A) manager, lubricating oil department, Marathon Oil Co., *Tulsa, Okla.;* (mail) P. O. Box 2064.

SMITH, JOHN PARKER (M) patent attorney, 724 First National Bank Building, *Chicago.*

STEWARD, CECIL HAROLD (A) automobile mechanic, Shell Oil Co. of California, *Long Beach, Calif.;* (mail) 1905 East First Street, Apartment L.

STUCKERT, FELIX J. (M) chief draftsman, Briggs & Stratton Corp., *Milwaukee;* (mail) 2572 North 46th Streeet.

TAYLOR, FIRST LIEUT. CLINT L., U. S. A. (S M) Field Artillery School, *Fort Sill, Okla.*

WEBSTER, COMMANDER WALTER W., U. S. N. (S M) chief, airplane design, Bureau of Aeronautics, Navy Department, *City of Washington.*

WHEELER, GEFFREY ERNEST (J) superintendent of mechanical maintenance, W. J. Wheeler & Sons, 29 Station Terrace, Green Lane, *Auckland, N. Z.*

WHITE, JOHN ALOYSIUS (M) branch manager, Mack International Motor Truck Corp., 1210 East 20th Street, *Baltimore.*

WYATT, LUCIAN H. (M) research engineer, field engineer, A. C. Spark Plug Co., *Flint, Mich.;* (mail) 2105 Concord Street.

News of the Sections

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initial energy of any fuel that can be converted into brake mean effective pressure. With as high volumetric efficiency as can be expected, the combustion efficiency and hence the power output may be increased by improved design of the combustion space, turbulence of the mixture, spark-plug location, manifolding, carburetion and improvement of the characteristics of the fuel. Slides of the C. F. R. test engine were shown and Mr. Fisher said that an interesting fact developed in connection with it was the clear distinction brought out between ignition and combustion of fuels, some igniting readily but burning relatively slowly and others igniting with difficulty but burning in an orderly and uniform way.

In conclusion, Mr. Fisher said that at no time has the demand for engineering leadership been so great as at present, and that the success or failure of many companies within the next two years rests on decisions now being made as to what they will build and how they will build it. Every phase of a new design must be carefully analyzed and utmost attention given to every detail. He emphasized the importance of contact of the engineers with operation of the engines in the field and with field representatives, and also of acquaintance with what is being done in other fields than the automotive industry. While specializing in their own particular lines has been of great value, it has the fault, he said, of giving us all a common viewpoint on our problems.

Octane Numbers Interest Baltimoreans

THEORIES around which octane numbers are used for indicating the antiknock qualities of hydrocarbon

(*Concluded on p.* 41)

Applicants for Membership

The applications for membership received between March 15 and April 15, 1932, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

BIGAREL, CLIFTON C., electrician, Eastern Greyhound Lines, *Syracuse, N. Y.*

BISHOP, WAYNE M., superintendent of motor-vehicles, Sun Oil Co., *Philadelphia.*

BRODIE, W. WARREN, president, B. & J. Auto Spring Co., *Brooklyn, N. Y.*

BROUILLETTE, THEODORE R., planning engineer, Aluminum Industries, Inc., *St. Cloud, Minn.*

BROWNE, CHARLES DENNIS, manager for Canada, C. C. Wakefield & Co., Ltd., *Toronto, Ont., Canada.*

CAMP, SAM D., engineer, Transportation Equipment Co., *Houston, Tex.*

CHALK, HAROLD, research engineer, Ethyl Gasoline Corp., *Detroit.*

CHAMPION, HARRY M., automotive engineer, Standard Oil Co. of New York, *Albany, N. Y.*

CLARY, R. M., service manager, General Motors Truck Co., *Kansas City, Mo.*

COHEN, SHELDON J., manager Toronto branch, Monarch Battery Mfg. Co., Ltd., *Kingston, Ont., Canada.*

DOPPEL, LEONARD, superintendent, engineer, Keystone Transportation Co., Inc., *New York City.*

DYKES, JOHN ALBERT, service manager, J. H. Early Motor Co., Ltd., *Saskatoon, Sask., Canada.*

ECKMAN, FRANK T., mechanical maintenance department, Greyhound Lines, *Cleveland.*

ERICSON, GEORGE R., patent counsel, Carter Carburetor Corp., *St. Louis.*

FRUEHAUF, ROY, sales engineer, Fruehauf Trailer Co., *Detroit.*

GARRICK, RUSSEL S., sales representative, Trico Products Corp., *Buffalo.*

GILE, TRUMAN, instructor in aeronautics, Automotive Trades High School, *Cincinnati.*

GRAF, JOSEPH, engineer, Graf & Stift, Ltd., Motor Car Works, *Vienna, Austria.*

GRAFTIAU, HENRI CHRETIEN LAMBERT, parts manager, motor department, Sedec, *Leopoldville, Belgian Congo, Africa.*

GRAY, ROY B., chief, division of mechanical equipment, Bureau of Agricultural Engineering, *City of Washington.*

GUINEE, C. R., factory manager, Spicer Mfg. Corp., *Pottstown, Pa.*

HEYDUCK, LAWRENCE E., First-Lieutenant, U.S.A., Field Artillery School, *Fort Sill, Okla.*

HIGGINSON, RICHARD HENRY, superintendent, Davis Tool & Engineering Co., *Detroit.*

HINCHMAN, HARVEY SHARPLESS, design draftsman, Naval Aircraft Factory, *Philadelphia.*

KAISER, ELWOOD P., draftsman, Boeing School of Aeronautics, *Oakland, Calif.*

KEESHIN, JOHN L., president, Keeshin Motor Express Co., *Chicago.*

KELLEY, EDWARD J., president, Automotive Ignition Co., Inc., *Pittsburgh.*

KISSINGER, CLAUDE E., assistant mechanical engineer, National Advisory Committee for Aeronautics, *Langley Field, Va.*

KLINE, WILLIAM L., engineer, Kline Mfg. Co., *Columbus, Ohio.*

KORBULY, LADISLAS, engineer, Manfred Weiss, *Csepel, Hungary.*

LAMBERT, CHARLES WADE, equipment engineer, Virginia State Highway Department, *Richmond, Va.*

LARSEN, AGNEW E., chief engineer, Autogiro Co. of America, *Philadelphia.*

LATHAN, A. E., field representative, Lathan Co., *San Francisco.*

LONG, RICHARD C., sales manager, Wheels, Inc., *New York City.*

LYONS, JOHN JOSEPH, JR., vice-president, Keelan Lyons Co., *Pittsburgh.*

MENGEDOHT, L. H., eastern sales manager, Waverly Oil Works Co., *Pittsburgh.*

MESARA, DOUGLAS K., mechanic, Packard Motor Car Co., *Detroit.*

NEWLIN, WILLIAM SIMS, salesman, Sun Oil Co., *Philadelphia.*

NIXON, STUART, western sales manager, Continental Motors Corp., *Detroit.*

OCHS, C. I., president and general manager, Eaton Mfg. Co., *Cleveland.*

PHILLIPS, ELLIS S., representative, Bendix-Westinghouse Automotive Air Brake Co., *North Braddock, Pa.*

PUZIK, OTTO V., checker, Auburn Automobile Co., *Auburn, Ind.*

RAKHMANOVICH, ANISIM, graduate student, Purdue University, *Lafayette, Ind.*

RATKE, CLEMENT J., shipping, Rouge Plant, Ford Motor Co., *Dearborn, Mich.*

ROSENQUEST, JOHN BUTLER, sales manager, General Motors Truck Co., *New York City.*

SCHNEIDER, C. L., sales manager, Fruehauf Trailer Co., *Detroit.*

SCOTT, MAURICE, assistant superintendent, department of water and power, City of Los Angeles, *Los Angeles.*

SHARP, MAJOR, representative, Bendix-Westinghouse Automotive Air Brake Co., *Pittsburgh.*

SHEPARD, CERVANTES A., vice-president, Inter-State Oil Co., *Kansas City, Kan.*

SIGHT, DAVID, secretary, Sight Bros. Motor Co., *Kansas City, Mo.*

SIMONDS, GEORGE DOUGLAS, sales engineer, Four Wheel Drive Auto Co., *Clintonville, Wis.*

SMEJKAL, DR. ING. MILOS, chief manager, Avia Aircraft Co., Ltd., *Prague, Czechoslovakia.*

TAUSSIG, WARREN A., general superintendent, Southwestern Transportation Co., *Texarkana, Tex.*

TAYLOR, SAMUEL BARTRAM RICHARDS, research assistant, Vacuum Oil Co., Inc., *Paulsboro, N. J.*

THAYER, HALSEY W., superintendent of transportation, department of water and power, City of Los Angeles, *Los Angeles.*

THORP, JOHN W., draftsman, Boeing School of Aeronautics, *Oakland, Calif.*

TURNER, ARCHIBALD ALBERT, regional parts and service manager, Chevrolet Motor Co., *Dallas, Tex.*

WADE, JAMES H., shop superintendent, The White Co., *Pittsburgh.*

WALDRON, CLOYD D., junior mechanical engineer, National Advisory Committee for Aeronautics, *Langley Field, Va.*

WILLETT, SYDNEY EDGAR, commercial manager, Titanic Works, Clayton Dewandre Co., Ltd., *Lincoln, England.*

WOLFE, HAROLD E., general parts and service manager, Nisbet Motor Co., Butler Motor Co., *Denver, Colo.*

News of the Sections

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fuels were thoroughly explained by Dr. Graham Edgar, director of research of the Ethyl Gasoline Corp., at the April 14 meeting of the Baltimore Section. The address was mainly divided between non-detonating and what the speaker termed "anti-knocking" fuels.

Through the greatly appreciated co-operation of the Waukesha Motor Co., a new C.F.R. fuel-testing engine was exhibited and its use was demonstrated by Mr. Winslow, of the company. The engine and Mr. Winslow's explanation of it added greatly to the interest of the meeting, which various members agreed was one of the most interesting of all the meetings held by the Section in its two years of activity.

An enlightening contribution to the subject of the evening was made in a talk by Dr. H. C. Dickinson, of the Bureau of Standards, who is a member of the Society's Research Committee and its Fuels Subcommittee. Among those who took leading parts in the subsequent general discussion were H. K. Cummings, of the Bureau of Standards; Eugene Bertone, of the Bertone Fuel Reaction Corp.; Adrian Hughes, Jr., of the United Railways & Electric Co. of Baltimore, and Laurance F. Magness, of the Hercules Power Gasoline Co.

The members' dinner, at which music was provided, was attended by 110, and the technical session by 122 members and guests. The affair was held in the Emerson Hotel ballroom.

Wichita Discusses Air Wheels

THE Application of Air Wheels was the subject on which Larry Guinther, of the Goodyear Tire & Rubber Co., addressed the Wichita Section at a meeting on March 28 at the Green Parrot Inn. The dinner meeting was attended by 31 members and guests, including the guests of honor, President A. J. Scaife and General Manager John A. C. Warner, of the Society.

Mr. Scaife addressed the gathering on Motor Transportation. and Mr. Warner spoke on membership and the affairs of the Society.

Mac Short, H. F. Brown, R. R. Higginbotham and Lewis G. Sinning took part in the discussion.

Notes and Reviews

AIRCRAFT

Application of Practical Hydrodynamics to Airship Design. By Ralph H. Upson and W. A. Klikoff. N.A.C.A. Report No. 405, 1931; 20 pp., 12 figs. Price, 15 cents. [A-1]

Drop and Flight Tests on NY-2 Landing Gears, Including Measurements of Vertical Velocities at Landing. By W. C. Peck and A. P. Beard. N.A.C.A. Report No. 406, 1931; 15 pp., illustrated. Price, 15 cents. [A-1]

The Characteristics of a Clark-Y Wing Model Equipped with Several Forms of Low-Drag Fixed Slots. By Fred E. Weick and Carl J. Wenzinger. N.A.C.A. Report No. 407, 1932; 9 pp., with tables and charts. Price, 10 cents. [A-1]

The Theory of Wind-Tunnel Wall Interference. By Theodore Theodorsen. N.A.C.A. Report No. 410, 1931; 11 pp., with tables and charts. Price, 10 cents. [A-1]

This paper outlines the development of a general theory for the calculation of the effect of the boundaries of the airstream on the flow past an airfoil.

The 7 x 10-Ft. Wind-Tunnel of the National Advisory Committee for Aeronautics. By Thomas A. Harris. N.A.C.A. Report No. 412, 1931; 9 pp., illustrated. Price, 10 cents. [A-1]

A Method for Computing Leading-Edge Loads. By Richard V. Rhode and Henry A. Pearson. N.A.C.A. Report No. 413, 1931; 12 pp. illustrated. Price, 10 cents. [A-1]

In this report a formula is developed that enables the determination of the correct design load for the portion of the wing forward of the front spar.

The Aerodynamic Characteristics of Airfoils at Negative Angles of Attack. By Raymond F. Anderson. N.A.C.A. Technical Note No. 412; 11 pp., 26 figs. [A-1]

Accurate Calculation of Multispar Cantilever and Semi-cantilever Wings with Parallel Webs under Direct and Indirect Loading. By Eugen Sänger. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt;* Vol. 22, No. 20, Oct. 28, 1931; Verlag von R. Oldenbourg, München und Berlin. N.A.C.A. Technical Memorandum No. 662; 18 pp., 3 figs. [A-1]

Problems Concerning the Stability and Maneuverability of Airplanes. By Jean Biche. Translated from *Revue de la Société Générale Aéronautique*, January, 1932. N.A.C.A. Technical Memorandum No. 63; 13 pp., 17 figs. [A-1]

The Mutual Action of Airplane Body and Powerplant. By Martin Schrenk. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt;* Vol. 22, Nos. 23 and 24, Dec. 14 and 28, 1931; Verlag von R. Oldenbourg, München und Berlin. N.A.C.A. Technical Memorandum No. 665; 35 pp., 25 figs. [A-1]

Static-Test and Stress-Distribution Studies of the Materiel Division 55-Ft. Cantilever All-Metal Wing. Air Corps Technical Report No. 3501. Published by the Chief of the Air Corps, City of Washington; Feb. 15, 1932; 62 pp., illustrated. [A-1]

L'Exploration de la Stratosphère par Avion. By François Baudot. Published in *La Technique Moderne*, Jan. 1, 1932, p. 5. [A-1]

Professor Picard's extraordinary free-balloon ascension to an altitude of 50,000 ft. has again called attention to the possibilities and advantages of lines of air travel far above the heights usually observed and the problems to be overcome in conquering the stratosphere.

Reference is made to the Paul Bert altitude chamber at the Bourget airport, where pressure and temperature conditions corresponding to altitudes up to 130,000 ft. can be reproduced, and a graph showing the conditions that exist at various altitudes up to about 65,000 ft. is given.

Finally, descriptions are given of three aircraft designed for travel in the upper atmosphere. The Farman, a French machine, is being developed by the French Air Ministry for scientific exploration at great altitudes. The Guerchais, a product of private French enterprise, has for its mission practical flights in the lower stratosphere. The German Junkers, like the Farman, is government subsidized for research purposes.

Jane's All-the-World's Aircraft, 1931. Compiled and edited by C. G. Grey and Leonard Bridgman. Published by Sampson Low, Marston & Co., Ltd., London; 575 pp., illustrated. [A-3]

"In spite of the much-advertised economic depression all over the world during the past year, the aircraft industries of the various nations have not done at all badly," is the opinion of the editors based upon the huge volume of data perused in compiling this comprehensive year book. They contend that the industry has had a useful weeding out but that the well-established firms have held their own.

The practical abandonment of wooden structures in favor of metal is noted as the outstanding general feature of airplane design, and arguments in favor of fabric and dope as a covering for wings and fuselages are advanced; the development of aircraft engines is characterized as a fight, along conventional lines, between the air-cooled and the water-cooled types, with considerable development work toward producing satisfactory heavy-oil engines; a distinct tendency toward air-cooled engines with the cylinders in line, in competition with large radial engines, is noted as well as the advisability of using engines that can be tucked away inside the wings to reduce head resistance. Reference is made to experiments in steam-cooling in Great Britain and in the use of Prestone cooling in the United States.

Special mention is made of airship development in the United States.

German Aircraft Accident Statistics, 1930. By Ludwig Weitzmann. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt;* Vol. 23, No. 1, Jan. 15, 1932; Verlag von R. Oldenbourg, München und Berlin. Technical Memorandum No. 664. Published by the National Advisory Committee for Aeronautics, City of Washington, March, 1932; 25 pp., 18 figs. [A-4]

Flugzeug-Unfallstatistik 1930. By Ludwig Weitzmann. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Jan. 14, 1932; p. 13. [A-4]

For the first time the German Institute for Aeronautical Research publishes in this report information on German aircraft-accident statistics that it has collected since 1926. Full statistics are given for 1930, and some comparative figures from previous years and from the records of this Country are also presented. Such reports are to be issued yearly in the future.

In the analytical grouping, the relationship between the causes, results, flight conditions and types of flight are traced. The proportion of accidents to flying hours is also given.

Summarizing the figures for the period covered, the number of accidents in proportion to flying hours is said to have decreased, as has the proportion attributable to powerplant, to outside influences and to commercial use.

(*Continued on next left-hand page*)

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

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KERITE
in three-quarters of a century of
continuous production,
has spun out a record
of performance
that is
unequalled in the
history of insulated
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NEW YORK CHICAGO SAN FRANCISCO

YOUR REQUIREMENTS GUIDE EACH OPERATION

A THOROUGH understanding of the problems of alloy steel users by the men who control the manufacturing processes is essential, if the steels are to give the highest possible satisfaction with respect to both service and behavior under operations in the user's plant.

Bethlehem metallurgists have always maintained close contact with the customer, resulting in intimate acquaintance with his requirements. Thus, every operation in the Bethlehem Alloy Steel Plant can be guided to produce steels that handle well under his shop operations and contribute to the quality of his product.

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Notes and Reviews

Continued

The Refuelling of Aircraft in Flight. By J. H. B. Larrard. Published in *The Journal of the Royal Aeronautical Society*, December, 1931, p. 1137. [A-4]

Reference is made to the experiments in refuelling in the air made in Germany and this Country and, on the assumption that the operation has been established as practical, its application to a hypothetical aircraft of the typical 20-place type is considered in detail and performance curves are plotted on the basis of the new take-off and all-up weights that refuelling in flight makes possible.

Die Deutsche Untersuchung des Unfalls bei Meopham (England). By Hermann Blenk, Heinrich Hertel and Karl Thalau. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Feb. 15, 1932, p. 73. [A-4]

The English investigation of the accident to the Junkers F-13, which occurred in England in July, 1930, and resulted in the death of six persons, indicated as the probable cause vibration of the horizontal tail surfaces and the consequent breakage of the control surfaces. All other ruptures were thought to be of a secondary nature.

Publication of this report led to another investigation by the German Institute for Aeronautical Research, which is the subject of this article. Attention was particularly directed to the buffeting, or vibration, of the horizontal tail surfaces, its causes, magnitude and dangers. The investigation included static and dynamic strength tests, and flight and wind-tunnel model tests.

CHASSIS PARTS

Fahrerleichterungen durch Neuzeitliche Getriebe und Selfattätige Kupplungen. By P. Grodzinski. Published in *Automobiltechnische Zeitschrift*, Jan. 10, 1932, p. 7. [C-1]

Modifications of conventional automotive powerplant, transmission and final-drive systems, recently made or considered to render easier the driver's task, are reviewed. They include overdimensioned engines; automatic clutches of the servo, vacuum or electromagnetic types; automatic gearshifts; free-wheeling; modified-gear and planetary transmissions; friction and hydraulic infinitely variable transmissions; mechanical torque converters and two-speed axles. Comments are made on the reactions of these mechanisms on driving technique and in particular on their application to small cars. A bibliography of about 40 German articles is appended.

Schäden an Kraftwagenrädern. By Professor Wawrziniok. Published in *Automobiltechnische Zeitschrift*, Dec. 31, 1931, p. 828. [C-1]

In this article an analysis is made of rim failures, in cases where these cannot be attributed to ill usage, accident or any other outside cause. The microscopic structure of two defective rims was examined and fine seams were found in a number of places, chiefly in the section at the bend in the rim. To ascertain how such seams were formed or accentuated, impact tests were made on a number of test pieces corresponding to the rim sections. Test pieces that had no seams in their original form were found to withstand impact about 15 times longer before breaking than pieces that were seamed. Indications of phosphorus were found in the defective pieces. Further microscopic examination of the rim material led to the conclusion that the seams were present in the original steel and were not formed during manufacture of the rims.

The conclusion reached is that steel for rim material should be specially low in phosphorus content and free from surface cracks, and that such specifications should be included in the automotive standards.

ENGINES

Valve Timing of Engines Having Intake Pressure Higher than Exhaust. By Edward S. Taylor. Technical Note No. 405; 7 pp., 9 figs. [E-1]

The Use of Large Valve Overlap in Scavenging a Supercharged Spark-Ignition Engine Using Fuel Injection. By Oscar W. Schey and Alfred W. Young. N.A.C.A. Technical Note No. 406; 10 pp., 6 figs. [E-1]

Effect of the Reservoir Volume on the Discharge Pressures in the Injection System of the N.A.C.A. Spray-Photography Equipment. By A. M. Rothrock and D. W. Lee. Technical Note No. 407; 9 pp., 7 figs. [E-1]

Preliminary Tests on the Vaporization of Fuel Sprays. By A. M. Rothrock. Technical Note No. 408; 4 pp., 4 figs. [E-1]

(Continued on next left-hand page)

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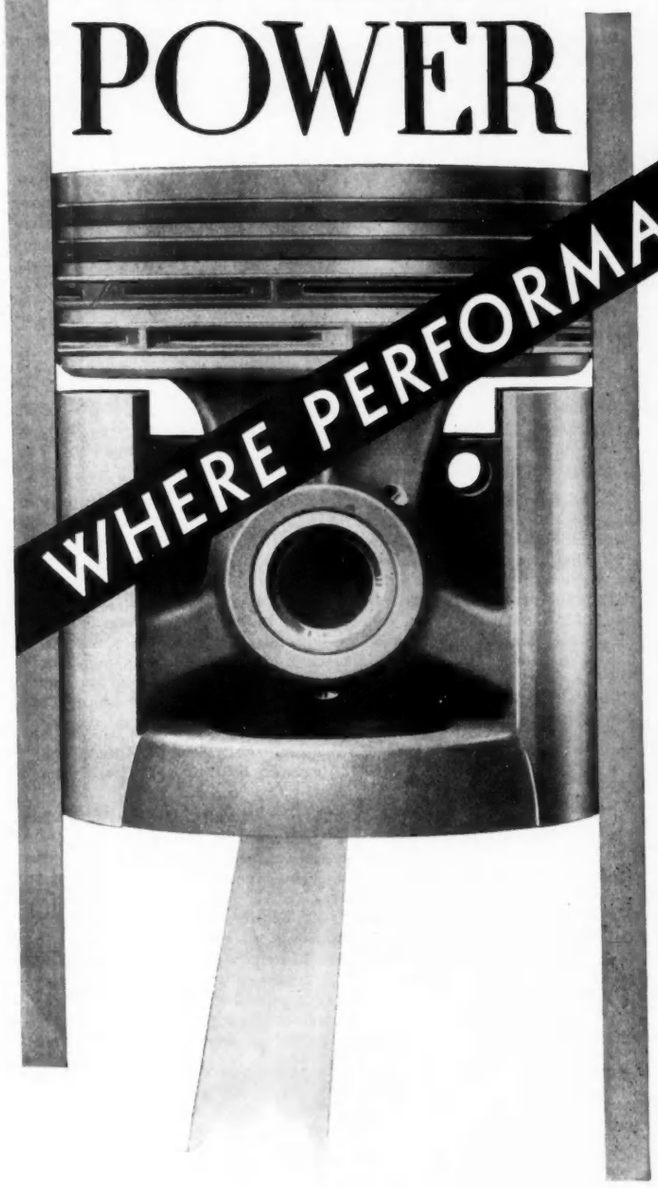

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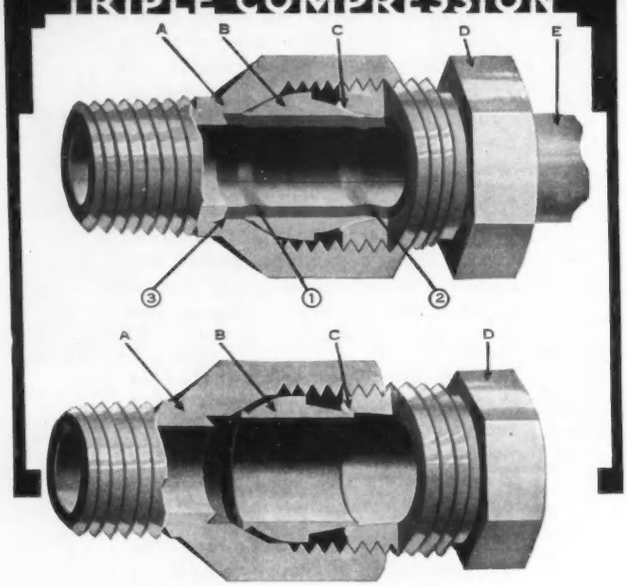

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Notes and Reviews

Continued

Experiments on the Distribution of Fuel in Fuel Sprays. By Dana W. Lee. N.A.C.A. Technical Note No. 410; 14 pp., 20 figs. **[E-1]**

Disintegration of a Liquid Jet. By A. Haenlein. Translated from *Forschung auf dem Gebiete des Ingenieurwesens*, Vol. II, No. 4, April, 1931. Technical Memorandum No. 659; 19 pp., 18 figs. **[E-1]**

The foregoing Technical Notes and Memorandum were issued during February, 1932, by the National Advisory Committee for Aeronautics, City of Washington.

The Elimination of Fire Hazard Due to Back Fire. By Theodore Theodorsen and Ira M. Freeman. Report No. 409. Published by the National Advisory Committee for Aeronautics, City of Washington, 1931; 9 pp., illustrated. Price, 10 cents. **[E-1]**

A critical study was made of the operation of a type of back-fire arrestor used to reduce the fire hazard in aircraft engines.

Vibration Characteristics of Aircraft Engine Crankshafts. Air Corps Technical Report No. 3533. Published by the Chief of the Air Corps, City of Washington; Feb. 23, 1932; 20 pp., illustrated. **[E-1]**

Oil-Film Pressures in an End-Lubricated Sleeve Bearing. By L. J. Bradford. Paper presented at the annual meeting of the American Society of Mechanical Engineers, New York City, Nov. 30 to Dec. 4, 1931. **[E-1]**

Data are given in this paper for oil-film pressures found in a bearing of 2½-in. diameter and 1⅞-in. length lubricated by oil supplied to circumferential grooves at both ends of the bearing and also at only one end. Clearances of 0.0005, 0.0043 and 0.0046 in. were used. It was found that no oil film could be established with the smallest clearance and that with the larger clearances conditions were unstable, but that the instability decreased as the load and clearance decreased. Evidence is given which indicates that the film is not continuous when the clearance is small and the load light. The author also shows that conditions are more stable when oil is supplied to both ends of the bearing than when supplied to only one end.

Die Reibungswiderstände des Flugmotors. By Kurt Löhner. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Jan. 28, 1932, p. 51. **[E-1]**

In measuring the frictional losses of aircraft engines, the German Institute for Aeronautical Research has made separate determinations of the friction due to moving parts and of pumping losses. Values obtained in the testing of two German engines are given and compared with the results found on American engines in the Bureau of Standards altitude chamber. The conclusion drawn is that pumping losses are responsible for almost as great a share of friction horsepower as is the mechanical friction of moving parts. An average value to be expected in proportion to piston speed and cylinder capacity is given. The mechanical efficiency of aircraft engines is stated to compare favorably with that of internal-combustion engines of other types.

Some Problems Connected with High-Speed Compression-Ignition-Engine Development. By C. B. Dicksee. Paper presented before a joint meeting of the Institution of Automobile Engineers and 10 other professional societies in London, March, 1932. **[E-1]**

The main problems to be solved, Mr. Dicksee contends, consist in devising suitable means for utilizing to the fullest possible extent the oxygen available within the cylinder and avoiding the production of smoke, noise and, insofar as it is connected with combustion conditions, odor.

Experimental work on these various phases of compression-ignition-engine development is reported and the process of combustion, the "delay period," fuels and engine knock are treated at considerable length.

A Review of the Piston and Cylinder Assembly in Relation to Oil Consumption. By E. C. Ottaway. Paper presented before the Institution of Automobile Engineers, London, Jan. 5, 1932. **[E-1]**

The author points out that he was unable to find any collected data concerning the performance in service of available pistons and cylinders of the various types and materials.

The facts and data given refer entirely to the author's experience obtained from the service running of motorcoaches and chiefly concern engines of motorcoach types.

The methods by which oil control can be obtained and the data relating to them are classified under four headings; namely (*a*) Control of Oil Reaching the Cylinder Walls, (*b*) Effect of Number and Arrangement of Rings and Use of Scraper Rings, (*c*) Piston Design and Effect of Piston Wear, (*d*) Effect of Cylinder Wear and Means of Reducing Such Wear.

(*Continued on next left-hand page*)

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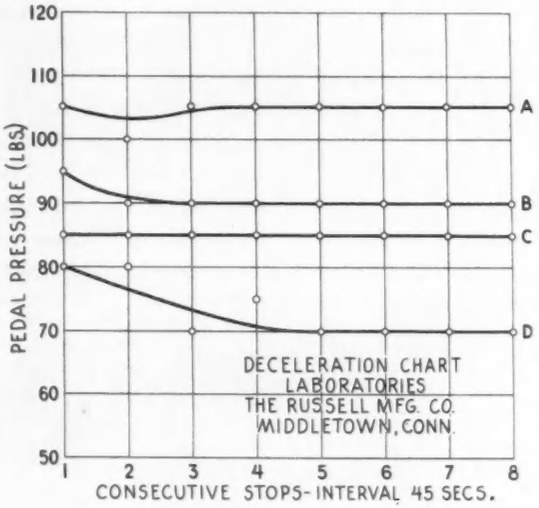

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Notes and Reviews

Continued

Les Possibilités Actuelles des Moteurs Diesel à Quatre Temps et à Deux Temps Suralimentés. By Marcel Gautier. Published in *La Technique Moderne*, Jan. 15, 1932, p. 43. **[E-1]**

Marcel Gautier, chief naval civil engineer, outlines herein some experiments made and some suggestions theoretically considered on the use of supercharging with four-stroke and two-stroke-cycle Diesel engines. The research described applies particularly to the marine type of Diesel, with an output of about 5000 hp. at 390 r.p.m. He claims that, if his theoretical conclusions are experimentally realized and the difficulties involved in their execution overcome, the total power provided for Diesel-engine cruisers may be increased from 96,000 to 123,000 hp.

In discussing four-stroke-cycle Diesels, the author outlines four different methods by which exhaust-gas turbine superchargers can be driven and compares their merits both as to the effect on engine operation and their weight and ease of installation. The operating results obtained from a four-stroke-cycle supercharged Diesel engine with air injection are then compared with those of an unsupercharged two-stroke-cycle engine with either air or solid injection, the advantage proving to be decidedly with the former.

The particular difficulties attending the supercharging of a two-stroke-cycle Diesel are summarized in introducing the second section of the article. Two methods of augmenting the supercharging air pressure are suggested.

Farm Gas Engines and Tractors. By Fred R. Jones. Published by the McGraw-Hill Book Co., Inc., New York City and London, 1932; 485 pp., illustrated. **[E-3]**

The material presented was collected and prepared by the author as a result of 15 years' experience in teaching the subject of farm power. In addition to its use as a textbook in agricultural colleges, the book is expected to prove helpful to instructors in vocational work dealing with farm-type engines and tractors, to mechanics and service men and to owners and operators of stationary engines and tractors.

The book is divided into two distinct parts. The first part deals with the fundamentals involved in the construction and operation of the simple internal-combustion engine, with particular application to the small, stationary farm-type engine. Following a brief discussion of early gas-engine development, such subjects as construction and operating principles, carburetion, ignition and lubrication are considered in complete detail, with respect to both early and recent developments.

The second part covers in a similar way the construction and operation of farm tractors of the various types. A special chapter has been prepared which deals with the fundamental requirements of the all-purpose or cultivating-type tractor and briefly describes the different makes now available, together with their outstanding features.

MATERIAL

Effect of Aging on Taut Rubber Diaphragms. By D. H. Strother and H. B. Henrickson. Technical Note No. 409. Published by the National Advisory Committee for Aeronautics, City of Washington, February, 1932; 7 pp., 2 figs. **[G-1]**

As part of an investigation of special compositions of rubber suitable for use as diaphragms for aircraft instruments, six samples were used as taut diaphragms in instruments and allowed to age for five years. Two of the instruments were in operating condition after this period of time, and one showed remarkably little change in performance. In making the rubber, tetramethyl thiuram disulphide was employed as a vulcanizing agent.

The Effect of Temperature on Some of the Physical Properties of Metals. By F. C. Lea and C. F. Parker. Published in *Engineering*, Jan. 1, 1932, p. 23. **[G-1]**

Herein the effect of temperature and stress upon metals is considered, primarily the phenomenon and methods of measurement of positive creep in relation to temperature and stress, with reference also to certain secondary effects that are of importance, especially in cases in which metals are subjected to high-temperature conditions for long periods of time.

Methods of determining the amount of creep at constant temperature are discussed at length, with the aid of diagrams and charts.

Part II of the paper appeared in the Jan. 8, 1932, issue of *Engineering*, p. 54, and covers the importance of control of the temperature, changes that may occur in materials when exposed to high temperatures, results of impact and hardness tests and changes in the microstructure of steels.

(*Continued on next left-hand page*)

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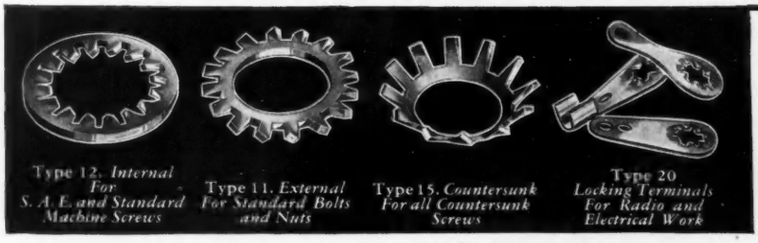

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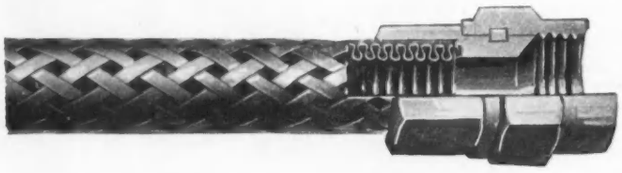

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Notes and Reviews

Continued

Rapid Chemical Test for the Identification of Chromium-Molybdenum-Steel Aircraft Tubing. By John C. Redmond. N.A.C.A. Technical Note No. 411; 3 pp. [G-1]

The Compressive Strength of Duralumin Columns of Equal-Angle Section. By Eugene E. Lundquist. N.A.C.A. Technical Note No. 413; 12 pp., 7 figs. [G-1]

Einsatzstähle. By Erich Eichwald. Published in *Automobiltechnische Zeitschrift*, Feb. 10, 1932, p. 59. [G-1]

In this summary of available case-hardening steels the author first lists commercial steels corresponding to those included in the German engineering standards and gives references wherein may be found the full data on these products. He then lists unstandardized case-hardening steels, giving their trade names, physical properties, heat-treatment and the automotive parts for which they are suitable. Krupp nitriding steels are similarly treated in a separate table. Graphs comparing the physical properties of alloyed and unalloyed steels are also included.

Structure of Cold-Drawn Tubing. By John T. Norton and R. E. Hiller. Paper presented before the American Institute of Mining and Metallurgical Engineers, New York City, February, 1932. [G-1]

The authors of this paper state that observations in practice reveal that different methods of bringing about the same dimension changes in a sample result in a rather wide range of properties. Cold working reduces the ductility of a metal, or its "working capacity." The fact has also been known for some time that cold deformation produces a parallel alignment of the crystal grains of a metal and that the type of this preferred orientation depends to some extent at least upon particular processes employed in the deformation.

The investigation reported in this paper had for its purpose the study of the relationship between the various factors of a cold-working process and the preferred orientation of the metal crystals resulting from this deformation. The work is chiefly confined to a study of cold-drawn seamless tubing.

Other papers of particular interest to the aircraft and automobile industry which were presented at the same meeting are:

Resistance of Iron-Aluminum Alloys to Oxidation at High Temperatures, by N. A. Ziegler.

Equilibrium Relations in Aluminum-Cobalt Alloys of High Purity, by William L. Fink and H. R. Freche.

Equilibrium Relations in Aluminum-Zinc Alloys of High Purity, by William L. Fink and Kent R. Van Horn.

Equilibrium Relations in Aluminum-Copper-Magnesium and Aluminum-Copper-Magnesium-Silicide Alloys, by E. H. Dix, Jr., G. F. Sager and B. P. Sager.

Etudes Expérimentales sur la Corrosion des Métaux. By Marcel Prot and N. Goldwoski. Published in *Le Génie Civil*, Jan. 9, 1932, p. 35. [G-1]

The investigation herein reported was undertaken to define a criterion for the corrosion susceptibility of a given metal or alloy in the presence of a given corrosive solution; in particular, of aluminum alloys in a salt solution approximating sea water.

So many variables influence the rate of corrosion of a metal that the ordinary experimental methods and expression of test results are said to lack accuracy.

An experimental method which is said to permit the characterization of the corrodibility of a metal by a precise index is described. The accuracy is obtained through a suitable definition of the initial surface of the test piece and of the procedure, particularly the concentration of the corrosive bath during the course of the test.

Le Graphite Colloïdal et l'Oildag. By H. Petit. Published in *La Technique Automobile et Aérienne*, 4th Quarter, 1931, p. 97. [G-1]

This discussion of colloidal graphite as an aid to lubrication consists of three parts: the reproduction of an article presented at the Lubrication Congress at Strasbourg in July, 1931, a report of certain experimental results and an exposition of the theoretical basis for the lubricating action of colloidal graphite.

In the first part, the origin of colloidal graphite is traced, its properties described and its functioning in reducing friction and resultant wear discussed. The material here presented is largely a summary of previous publications and reports of experiments.

The experimental results include tests made on a Chevrolet engine, first with ordinary oil and then with oil treated with graphite, with the result in the latter case of an 8.85-per cent

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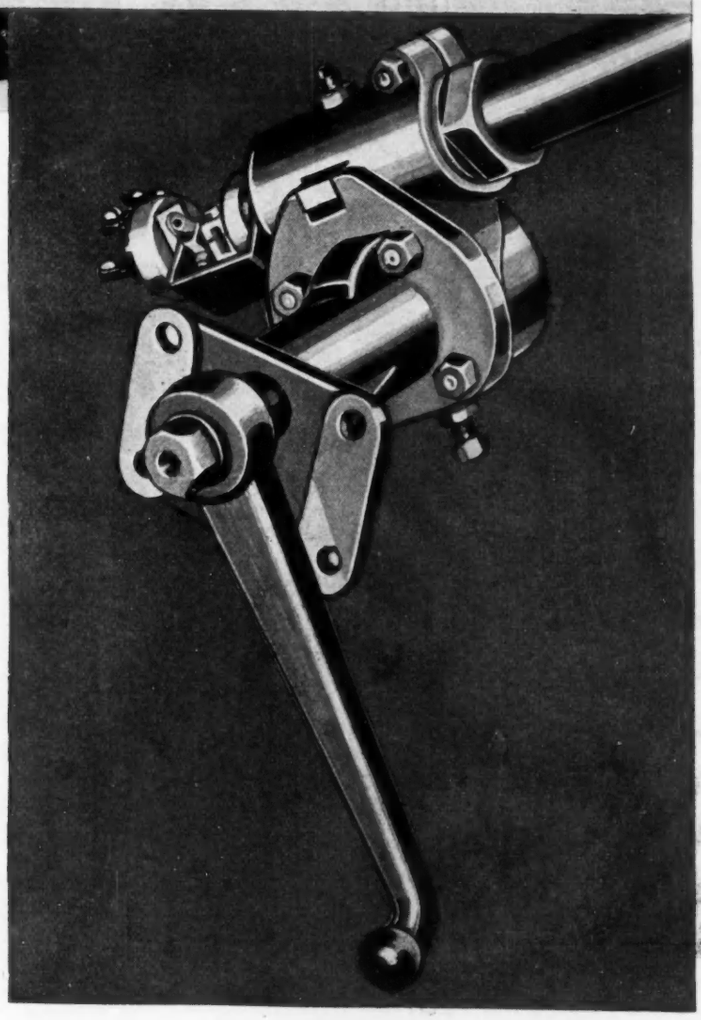

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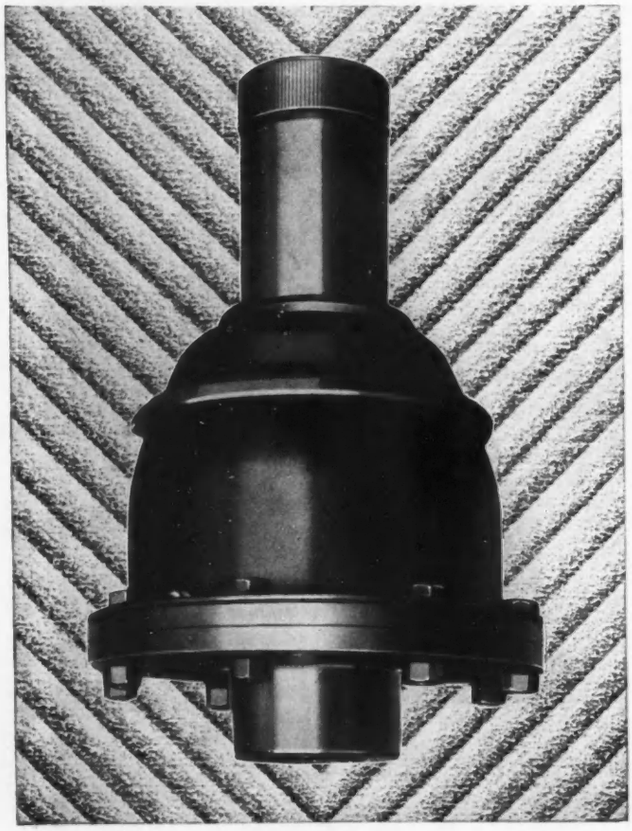

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Notes and Reviews

Continued

decrease in the starting torque, a 4.5-per cent decrease in gasoline consumption and an increase of 4.5 per cent in thermal efficiency. Reference is also made to the benefits of using graphite in running-in new engines.

MISCELLANEOUS

Friction of Some Babbitt Roller and Ball Bearings. By Edward R. Maurer and E. A. Kelso. Engineering Experiment Station Series No. 72. Published by the University of Wisconsin, Madison, Wis., 1931; 48 pp. **[H-1]**

A test plant for investigating the friction of lineshaft bearings was installed in the University of Wisconsin in 1909. The calculated friction data were in all cases the average for 20 like bearings.

In 1913 the work of Professors Maurer and Kelso, together with some earlier work, was reported to the American Society of Mechanical Engineers. Later, a testing plant with which two or three kinds of bearing could be tested simultaneously in the same room was considered desirable and, accordingly, a second plant was constructed.

The present report deals, not only with the tests made since 1913, but includes much of the material reported to the A.S.M.E in that year.

The general purpose of all tests was to determine the friction of some commercial lineshaft bearings under circumstances to warrant some fair comparisons of their frictional resistances. The testing of a a large number of bearings of each kind and the simultaneous testing of several kinds are regarded as the unique and important features of these investigations.

Das Messen von Beschleunigungen im Kraftwagenbetriebe. By Josef Geiger. Published in *Automobiltechnische Zeitschrift*, Jan. 25, 1932, p. 31. **[H-1]**

Instruments for the continuous recording of horizontal accelerations in bringing a vehicle up to speed and decelerations to bring it to a standstill are the subject of this article. The author differentiates between two types of spring accelerometer: those in which the weight is held against a seat by a spring and is raised from it by a predetermined force, thus breaking an electrical contact; and those in which the weight is held in a state of equilibrium by the spring, is removed from this state by acceleration and returns to it immediately and without oscillation.

A mathematical analysis of the latter type of instrument is made, an accelerometer based on these principles is described, records of horizontal acceleration obtained are reproduced and application of the instrument to rotary and vertical movements is explained.

La Mesure du Bruit—La Cellule Photo-Electrique et l'Automobile. By Marc Chauvierre. Published in *Journal de la Société des Ingénieurs de l'Automobile*, February, 1932, pp. 1650 and 1658. **[H-1]**

In this article entitled Noise Measurement and the Photo-Electric Cell and the Automobile, the author first emphasizes the necessity of some type of instrument to replace the human ear in the measurement of automobile noise. He outlines some principles of acoustics to show how difficult the exact quantitative measurement of sound is, and suggests as a satisfactory substitute in automotive research a simple relative measurement in which the variations in sound intensity are translated into the movement of a needle on a dial. Such a test apparatus can be realized by the use of radio devices, a microphone, a sound filter, an amplifying voltmeter and a milliammeter. Refinements of such an instrument to make its reading correspond to the sensibility of the human ear or to render it sensitive only to sounds within a certain range of frequency are suggested.

Uses suggested for the photo-electric cell are in the measurement of low vehicle speeds, where the ordinary chronometer is at a disadvantage, the signaling of an approaching vehicle at road intersections, the counting of pieces on a production line, the automatic lighting of headlights at nightfall and the control of illumination in a tunnel in proportion to the amount of natural light available. An example of the last-named use in operation in France is given.

Wages and the Road Ahead. By James D. Mooney. Published by Longmans, Green & Co., New York City, 1931; 149 pp. **[H-3]**

Trained economists will find little that is new in this book by the author of *Onward Industry*, but the man in the street will discover within its covers a clear statement of the present situation and some pertinent suggestions as to how we may hope to

(*Continued on second left-hand page*)

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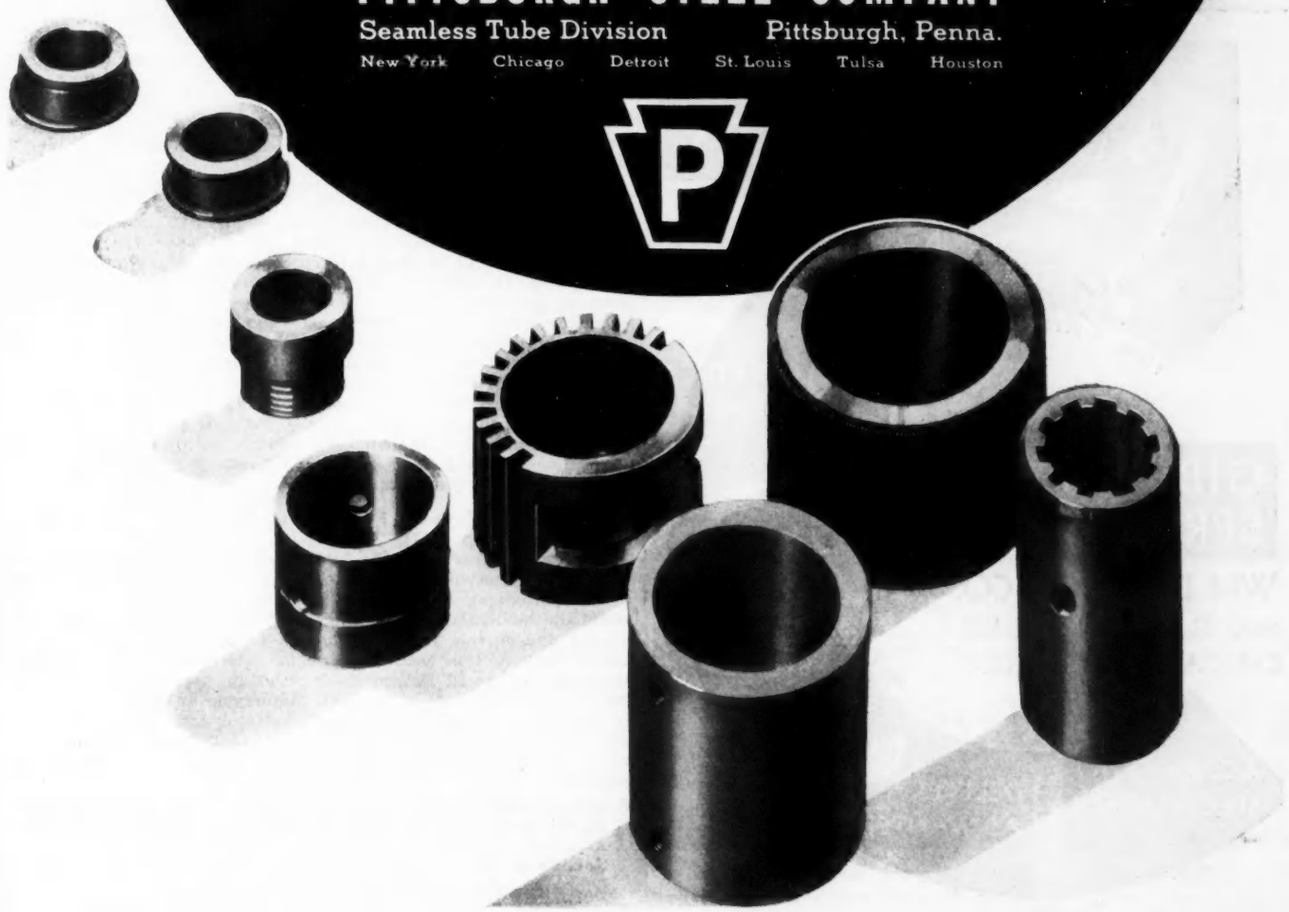

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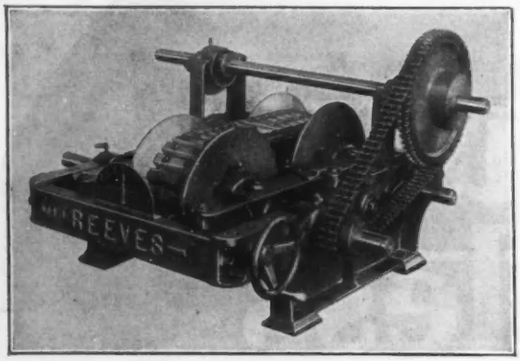

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Notes and Reviews

Continued

get out of it. Mr. Mooney believes in the gospel of work and plenty of it. He pleads for a rational view of the conditions which surround the problem and believes we should waste no time in further speculation or search for leadership, but "get busy," return to the full use of the old-time virtues and, individually, pull ourselves out of depression in which we find ourselves. Discussing wage reduction, he advises workmen to do whatever will "break the jam"; taking a reduction if necessary and making up for it later through production and hard work.

Robert Bosch und Sein Werk. By Conrad Matschoss. Published by the VDI Verlag, Berlin, Germany. 126 pp.; 124 illustrations. **[H-3]**

An inventive genius, an untiring research worker, a courageous and faith-inspired pioneer, a broad-visioned organizer, a practical executive, a writer on social and political topics, an educator and a philanthropist—this is the Robert Bosch portrayed in the biography published by the German association of engineers to mark the 70th birthday of one of the foremost men of their profession.

Robert Bosch's story is followed from the time of his youth, early formative years of study and travel. The sowing of those first tiny seeds of his later impressive industrial enterprises is described, as are also the years of research that led to the production of the high-tension magneto in 1902. From this dates the rise of Robert Bosch to world eminence. Later followed the production of generators, head-lamps, central lubricating systems, post-war reorganization and his entry into the field of Diesel-fuel systems.

As a final tribute, the biography recounts how, as Bosch extended his commercial enterprises, he intensified his interest in human problems, in the mental and physical welfare of his employes and in the education and standing of German engineers in general.

Quelques Problèmes Actuels de l'Industrie Automobile. By Charles Faroux. Published in *Journal de la Société des Ingénieurs de l'Automobile,* January, 1932, p. 1618. **[H-3]**

The most pressing problem of the automobile industry today, according to the author of this article, is the discovery of a machine for the large-scale production of customers. So many and so intricately interwoven are the factors influencing automotive prosperity that the single element of engineering cannot be considered independently.

In his discussion, M. Faroux aims to set forth the most vital facts, both technical and commercial, that confront the industry. From the fact that automobiles are obsolescent long before they are outworn, he concludes that substantial progress is being made in design. He comments on the continuing increase in engine speed and compression, with the concommitant developments in fuels, engine materials and balance. He discusses the four-speed transmission with silent third speed, predicts profound radical changes in the silhouette of the automobile in the near future and, in this connection, reviews briefly the questions of free-wheeling, independent-wheel suspension, rear location of the engine and streamlining, and urges that the technical value of an innovation and not the difficulty of perfecting it be the factor in deciding upon its development.

The used-car problem, the plan of André Citroën for the exploitation of the automobile in the 107 countries that have no automotive industry of their own, and the attitude of the French Government toward the industry are the three commercial phases to which most attention is directed.

The Engineering Outlook. Published in *Engineering*, Jan. 1, 1932, p. 17. **[H-3]**

This series of articles, the first of which appears in the Jan. 1 issue of *Engineering,* has become established as a yearly feature of the periodical. Available statistics indicating the status and trend of the British engineering industry are presented and discussed, and on this basis a prediction for the forthcoming year is made. Article I is entitled, Economic Retrospect and Prospects for 1932; article II, Electrical Engineering, appears in the Jan. 8 issue of *Engineering;* article III, Motorcycle and Cycle Industry, in the Jan. 15 issue; article IV, The Motor Industry, in the Jan. 22 issue; and article V, The Aircraft Industry, in the Jan. 29 issue. Other engineering fields will be covered in succeeding articles.

Application and Design of the Floating Drive for Conveyors. By N. H. Preble. Paper presented at the annual meeting of the American Society of Mechanical Engineers, New York City, Nov. 30 to Dec. 4, 1931. **[H-5]**

(*Continued on next left-hand page*)

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. . . adopted as Regular Factory Equipment by 10 CAR MANUFACTURERS

CENTRIFUSE Brake Drums

At this year's automobile shows, the adoption of Centrifuse Brake Drums as regular factory equipment was announced by one large car manufacturer.

Today, barely 4 months later, Centrifuse Brake Drums are featured by 10 leading car makers, as standard equipment for cars ranging all the way from the *highest-priced products* of the industry to the *lowest-priced models*.

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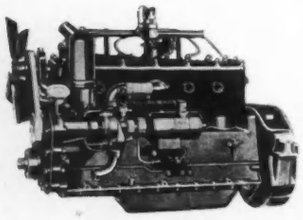

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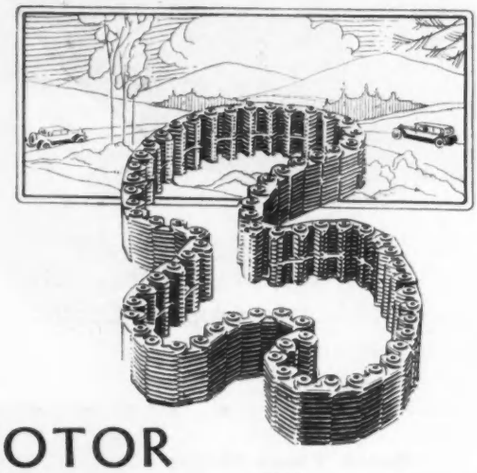

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The new WHITNEY Anti-Whip Timing Chain resists vibration to a high degree and at the same time, retains its long life characteristics.

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WHITNEY TIMING CHAINS

Notes and Reviews

Continued

Increasing demand for longer conveyors and conveyors more heavily loaded per foot of length has brought about the necessity of using multiple drives on a single strand of conveyor chain in order to keep the weight and cost of chain and carrier units down to a reasonable point. To meet this requirement, a floating type of driving mechanism has been developed which is arranged so that two or more drives located at a considerable distance from each other will automatically synchronize as to speed so that correct driving action will be maintained at each drive point. The author describes in detail the development of this design and its application to conveyors of various types and points out the advantages obtained through its use, not only as a synchronizing means, but also in correctly distributing the total load, effecting smoother operation, and in replacement of the standard form of shear pin.

Economic Life of Equipment. By H. O. Vorlander and F. E. Raymond. Paper presented at the annual meeting of the American Society of Mechanical Engineers, New York City, Nov. 30 to Dec. 4, 1931. **[H-5]**

The correct solution of the problems of how to select and when to replace equipment is vital to industry. Accordingly, the A.S.M.E. sponsored a research project to investigate this subject thoroughly and formulate the principles upon which any equipment policy should be based and out of which practical technique can be evolved for the usual purposes of industry. As a result, this paper, which constitutes the formal report on the project, presents criteria for the economic or useful life of equipment, the determination of depreciation policies, the ultimate ability of equipment to produce earnings or profits, for protection from the hazard of impending obsolescence, and for the guidance of equipment manufacturers in the evolution of new designs and in anticipating the needs of industry.

MOTOR-TRUCK

Le Gazogène à Bois et son Application aux Véhicules Industriels. By M. Cézanne. Published in *Journal de la Société des Ingénieurs de l'Automobile*, December, 1931, p. 1578; d. p. 589, **[K-1]**

That gas-producer trucks were used in the French army maneuvers last year for the transport of troops in the combat zone is cited as significant evidence in favor of the gas-producer type of powerplant.

The author confines his discussion to gas-producer units burning as primary fuel, not charcoal or specially prepared wood, but wood commercially known as dry wood and generally widely available. The problems involved in the use of such fuel are stated to be how to obtain regularity in the production of gas in spite of the variation in quality, dimensions and humidity of the fuel; the elimination of harmful by-products such as tar and acids, and the disposition of cinders.

A gas-producer unit which the author asserts solves these problems is described and the results of its use in 10 trucks in the military trials are summarized. Regularity and reliability of functioning, satisfactory power, distinct economy and ease of service are among the advantages claimed to have been demonstrated. Turning to commercial applications, the author summarizes the design features of a vehicle built especially for the use of producer gas as fuel and points out what modifications must be made in gasoline driven motor-trucks if a gas-producer unit is to be installed. Finally he cites figures to show that a gas-producer-fueled truck would show, over 5 years of operation, an economy of 20 per cent as compared with a gasoline-driven vehicle.

Les Remorques pour le Transport des Lourdes Charges par Tracteurs Automobiles. Published in *Le Génie Civil*, Feb. 27, 1932, p. 215. **[K-1]**

Trailers for the transport of heavy loads are becoming increasingly popular in France, says the author, who describes in some detail the construction of certain special-purpose types. These include the Scemia trailers for carrying railroad freight cars, a Coder vehicle with an automatic hitch, a Citroen passenger-carrying trailer for the transport of factory workers and the varied line of Sulitzer trailers for loads ranging up to 21 tons.

Motors. By Lieut.-Col. B. F. Miller. Published in *The Quartermaster Review*, November-December, 1931, p. 35. **[K-4]**

This article comprises a brief history of Army motor transportation and a statement of its functions, prepared under the direction of the Quartermaster General at the Motor Transport School, Holabird Quartermaster Depot, Baltimore.

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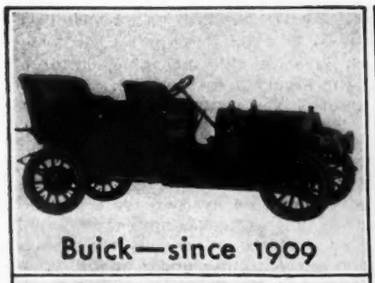
Buick—since 1909

Oldsmobile—since 1910

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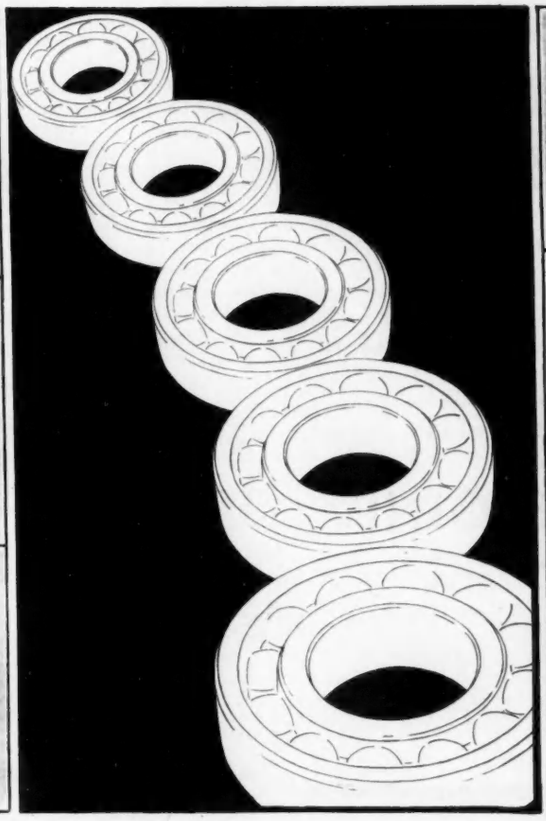
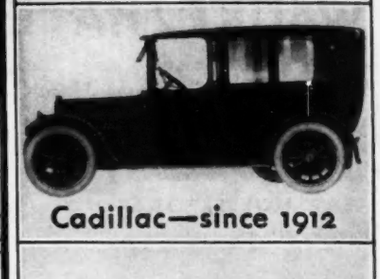


Marmon—since 1912

Chevrolet—since 1913


Cadillac—since 1912

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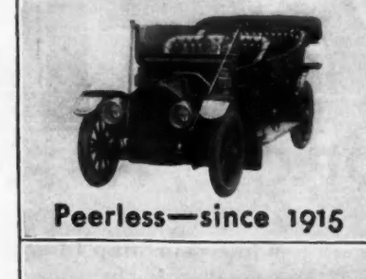
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Notes and Reviews
Concluded

PASSENGER CAR

Autour des Essais de Voitures. By Henri Petit. Published in *La Vie Automobile*, Oct. 25, 1931, p. 557. [L-1]

In all his testing of stock cars for this magazine, states the author, he never has found one accurate speedometer. The most modest errors are advances of 5 per cent. Mileage odometers are correctly calibrated in about 30 per cent of the cars tested.

This article tells how the performance tests, the results of which are published in *La Vie Automobile*, are initiated and carried out and the reports formulated.

Road tests are made of maximum and average cruising speed, acceleration, stopping distances and fuel consumption. The published report usually also contains comments on the general behavior of the car, such as maneuverability and roadability.

Chevrolet-Six Car and Truck. By Victor W. Pagé. Published by the Norman W. Henley Publishing Co., New York City, 1932; 489 pp. [L-3]

This book is a practical treatise, written in simple language, explaining the functions and construction of all parts of Chevrolet-Six cars and trucks, with complete instructions for operation, maintenance and lubrication. The author points out that the volume of production and the wide distribution of this make of car warrant this special book on its repair and maintenance.

Expert Driving. By H. L. McCann and James O. Spearing. Published by Transportation Engineering Service, Inc., Brooklyn, N. Y., 1931; 106 pp. [L-4]

This manual is divided into two parts. Part I is intended, primarily, for new drivers and is meant to give them the benefit of knowledge usually acquired slowly, and sometimes expensively, by experience. This section contains, however, much helpful information for experienced operators.

Part II is intended for the use of all drivers. It consists of approximately 200 different hints on the purchase, operation and maintenance of an automobile, with suggestions on how to avoid difficulty, to get out of trouble and to reap the maximum enjoyment from a motor-car.

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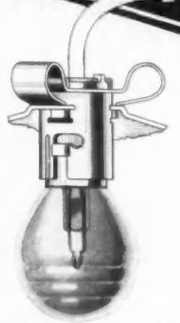

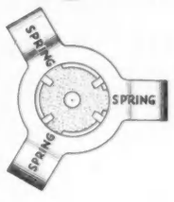

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